2009-12

Analysis of the distribution of vaccine using Department of Defense assets versus contracts with private-sector delivery companies

Latta, Jason E.

Monterey, California. Naval Postgraduate School

NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

THESIS

ANALYSIS OF THE DISTRIBUTION OF VACCINE USING DEPARTMENT OF DEFENSE ASSETS VERSUS CONTRACTS WITH PRIVATE-SECTOR DELIVERY COMPANIES

by

Jason E. Latta

December 2009

Thesis Advisor: Aruna Apte
Second Reader: Geraldo Ferrer

Approved for public release; distribution is unlimited

THIS PAGE INTENTIONALLY LEFT BLANK

REPORT DOCUMENTATION PAGE	*Form Approved OMB No. 0704-0188*

1. AGENCY USE ONLY *(Leave blank)*	**2. REPORT DATE** December 2009	**3. REPORT TYPE AND DATES COVERED** Master's Thesis

4. TITLE AND SUBTITLE Analysis of the Distribution of Vaccine Using Department of Defense Assets Versus Contracts with Private-Sector Delivery Companies

5. FUNDING NUMBERS

6. AUTHOR(S) Jason E. Latta

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Naval Postgraduate School
Monterey, CA 93943-5000

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING /MONITORING AGENCY NAME(S) AND ADDRESS(ES)
N/A

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES The views expressed in this thesis are those of the author and do not reflect the official policy or position of the Department of Defense or the U.S. Government.

12a. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release; distribution is unlimited	**12b. DISTRIBUTION CODE**

13. ABSTRACT (maximum 200 words)

It is not a question of "if" the next pandemic influenza outbreak will strike, but "when." The current plan for vaccine distribution that the Department of Defense (DoD) has in place is to extend contracts to civilian delivery companies such as the United Parcel Service (UPS) or Federal Express (FedEx). According to the *National Strategy for Pandemic Influenza* signed by then President Bush in 2005, as much as 40% of the population could be incapacitated if a pandemic influenza were to occur in the United States. If the DoD depends on civilian delivery companies to distribute the vaccine, it will be competing with the Centers for Disease Control (CDC) (responsible for distributing vaccine to the civilian population) for use of these services. This thesis will analyze whether it might be safer and more efficient to use DoD assets to make vaccine deliveries during a pandemic situation, instead of extending the usual delivery contracts with FedEx and UPS at a time when the availability and reliability of civilian delivery companies may be compromised.

This thesis will first conduct a literature review of the history of pandemic influenza outbreaks in the United States and the responses to each outbreak. It will then analyze the current plans that are in place to vaccinate the DoD, as well as the civilian populations should an outbreak occur. Next, a model will be constructed that minimizes the amount of time before all Marine Corps active duty, dependents, and DoD civilian employees receive vaccination. The scope of the model will cover the seven Marine Corps installations on the eastern seaboard of the continental United States. Constraints of the model will include the total population at each of the seven installations that must receive vaccination, the daily capacity of the numerous Medical Treatment Facilities (MTF) at each installation, the speed with which various modes of transportation can deliver the vaccine, the cargo capacity of the various modes of transportation, and the feasibility of patients travelling to other installations to receive vaccinations if their home MTF is at capacity.

The research in this thesis builds on but is different from the Jones/Tecmire MBA Project entitled "Cold Chain Logistics: A Study in the Department of Defense OCONUS Pre-Pandemic Influenza Vaccine Distribution Network" (2007). The research in that MBA Project studied the process of delivering vaccine to the Pacific Command in Southeast Asia but stopped the analysis of the supply chain once the vaccine arrived in country. This thesis will analyze the process of delivering the vaccine the "last tactical mile" down to actually administering the vaccine to individuals and whether it is safer and more efficient to use DoD assets versus extending contracts to civilian delivery services.

14. SUBJECT TERMS Pandemic Influenza, Vaccine Distribution, Vaccine Distribution with DoD Assets, DoD Pandemic Influenza Response Plan

15. NUMBER OF PAGES 81

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	**18. SECURITY CLASSIFICATION OF THIS PAGE**	**19. SECURITY CLASSIFICATION OF ABSTRACT**	**20. LIMITATION OF ABSTRACT**
Unclassified	Unclassified	Unclassified	UU

NSN 7540-01-280-5500 | Standard Form 298 (Rev. 2-89) Prescribed by ANSI Std. 239-18

THIS PAGE INTENTIONALLY LEFT BLANK

Approved for public release; distribution is unlimited

ANALYSIS OF THE DISTRIBUTION OF VACCINE USING DEPARTMENT OF DEFENSE ASSETS VERSUS CONTRACTS WITH PRIVATE-SECTOR DELIVERY COMPANIES

Jason E. Latta
Captain, United States Marine Corps
Exercise Physiology, University of South Florida, 1999

Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN MANAGEMENT

from the

NAVAL POSTGRADUATE SCHOOL
December 2009

Author: Jason E. Latta

Approved by: Professor Aruna Apte
Thesis Advisor

Professor Geraldo Ferrer
Second Reader

Dr. William Gates, Dean
Graduate School of Business and Public Policy

THIS PAGE INTENTIONALLY LEFT BLANK

ABSTRACT

It is not a question of "if" the next pandemic influenza outbreak will strike, but "when." The current plan for vaccine distribution that the Department of Defense (DoD) has in place is to extend contracts to civilian delivery companies such as the United Parcel Service (UPS) or Federal Express (FedEx). According to the *National Strategy for Pandemic Influenza* signed by then President Bush in 2005, as much as 40% of the population could be incapacitated if a pandemic influenza were to occur in the United States. If the DoD depends on civilian delivery companies to distribute the vaccine, it will be competing with the Centers for Disease Control (CDC) (responsible for distributing vaccine to the civilian population) for use of these services. This thesis will analyze whether it might be safer and more efficient to use DoD assets to make vaccine deliveries during a pandemic situation, instead of extending the usual delivery contracts with FedEx and UPS at a time when the availability and reliability of civilian delivery companies may be compromised.

This thesis will first conduct a literature review of the history of pandemic influenza outbreaks in the United States and the responses to each outbreak. It will then analyze the current plans that are in place to vaccinate the DoD, as well as the civilian populations should an outbreak occur. Next, a model will be constructed that minimizes the amount of time before all Marine Corps active duty, dependents, and DoD civilian employees receive vaccination. The scope of the model will cover the seven Marine Corps installations on the eastern seaboard of the continental United States. Constraints of the model will include the total population at each of the seven installations that must receive vaccination, the daily capacity of the numerous Medical Treatment Facilities (MTF) at each installation, the speed with which various modes of transportation can deliver the vaccine, the cargo capacity of the various modes of transportation, and the feasibility of patients travelling to other installations to receive vaccinations if their home MTF is at capacity.

The research in this thesis builds on but is different from the Jones/Tecmire MBA Project entitled "Cold Chain Logistics: A Study in the Department of Defense OCONUS Pre-Pandemic Influenza Vaccine Distribution Network" (2007). The research in that MBA Project studied the process of delivering vaccine to the Pacific Command in Southeast Asia but stopped the analysis of the supply chain once the vaccine arrived in country. This thesis will analyze the process of delivering the vaccine the "last tactical mile" down to actually administering the vaccine to individuals and whether it is safer and more efficient to use DoD assets versus extending contracts to civilian delivery services.

TABLE OF CONTENTS

LIST OF FIGURES

THIS PAGE INTENTIONALLY LEFT BLANK

LIST OF TABLES

THIS PAGE INTENTIONALLY LEFT BLANK

ACKNOWLEDGMENTS

To my wife, Hilary, and our children, Jack and Caroline, I extend my deepest gratitude and love. They have been unwavering supporters throughout this endeavor. I would also like to thank my advisors, Professors Aruna Apte and Geraldo Ferrer for their time, advice, and valuable guidance throughout the development of this thesis.

THIS PAGE INTENTIONALLY LEFT BLANK

I. INTRODUCTION

A. BACKGROUND

The World Health Organization (WHO) has issued a statement saying that it is not a matter of if the next pandemic influenza will strike, but when (WHO, 2009). As with any natural disaster, the foremost concern is supplying those in need with critical relief supplies. In the matter of a pandemic influenza outbreak, critical relief supplies come in the form of anti-viral medication, ventilators, and vaccine. Of these three materials, the vaccine is the only one that would be administered to every individual in an area affected by pandemic influenza. The Department of Defense (DoD) is responsible for providing vaccine for all active duty, civilian employees, and their dependents in the event of a pandemic influenza outbreak (DoD, 2006).

There is no standard distribution plan for how critical pandemic influenza vaccine will be delivered to the various medical treatment facilities (MTFs) aboard the military installations (Jones & Tecmire, 2007). None of the current policies regarding DoD pandemic influenza response plans outline specifically how vaccine will be delivered to MTFs except to say that "the DoD will supply installations with vaccine for designated military personnel, medical staff, and other high-risk individuals and that the MTFs aboard the installations will obtain vaccine through their usual logistics mechanism or their state or local health department" (DoD, 2006). The DoD's standard logistics mechanisms for vaccine distribution are to utilize the methods of contracting private-sector delivery companies such as United Parcel Service (UPS) and Federal Express (FedEx) (Jones & Tecmire, 2007). According to the *National Strategy for Pandemic Influenza* signed by President Bush in 2005, as much as 40% of the population could be incapacitated if a pandemic influenza were to occur in the United States. If the DoD depends on civilian delivery companies to distribute the vaccine, it will be competing for the use of these services with the Centers for Disease Control and Prevention (CDC), which is responsible for distributing vaccine to the civilian population. The intent of this thesis is to analyze whether it might be safer and more efficient to use DoD assets to make vaccine deliveries at installations during a pandemic situation instead of extending the usual delivery contracts with FedEx and UPS at a time when the availability and reliability of civilian delivery companies may be compromised. The researcher will conduct this analysis by identifying the variables that must be considered to construct a distribution model that minimizes the amount of time to transport and administer vaccine to a given population. Chapter I includes the background, objective, scope and methodology of the thesis. Chapter II contains a history of pandemic influenza in the United States, the current DoD response initiatives to a pandemic influenza outbreak, as well as the current CDC response initiatives to pandemic influenza. Chapter III will describe the population makeup, MTF capacities, transportation assets available, and the distances between each of the seven installations and their respective MTFs. The fourth chapter will describe the models that are used and the results that are reached. The conclusion will follow in Chapter V.

B. OBJECTIVE

The objective of this project is to compare the current plan for distribution and delivery of vaccine versus the utilization of DoD assets in the vaccine supply chain. The researcher will do this by constructing a mathematical model that minimizes the amount of time necessary to administer pandemic influenza vaccine including constraints for population, time, characteristics of assets available, and MTF daily capacities.

C. SCOPE

The “last-mile distribution” phase occurs when vaccine is delivered from a local distribution center (LDC)—an airport or supply hub—to the MTFs to be administered to the population (Balcick, Beamon & Smilowitz, 2008). The analysis of the model will focus on this phase of vaccine delivery and dispensing. The researcher will analyze the two models to achieve the objective of minimizing the amount of time to dispense pandemic influenza vaccine to the population. Model 1 will focus on the delivery of vaccine from the LDC to the MTFs, constrained by the characteristics of a combination of air and vehicular assets. Model 2 will concentrate on the MTF daily vaccination capacities, constrained by the number of vaccinations they can support each day. The population in the MTF areas of responsibility (AOR) will be the determining variable in both models, as the population will determine how much vaccine must be transported (Model 1) and how many days it will take to vaccinate the said population based on MTF daily capacity (Model 2). A simulated scenario of conducting a mass vaccination will be constructed using the Arena 10.0 simulation program.

The scope of the affected area in the simulation will include the seven Marine Corps installations on the eastern seaboard of the United States. They include Marine Corps Logistics Base (MCLB) Albany, GA; Marine Corps Recruit Depot (MCRD) Parris Island, SC; Marine Corps Air Station (MCAS) Beaufort, SC; Marine Corps Base (MCB) Camp Lejeune, NC; MCAS New River, NC; MCAS Cherry Point, NC; and MCB Quantico, VA. These locations are depicted in Figure 1.

Figure 1. East Coast Marine Corps Installations (After: Google Maps)

Each situation that arises from a pandemic influenza outbreak is unique based on its severity and location. The two models developed in this thesis are flexible and can be applied to various locations or AORs by adjusting the population numbers and available assets to match the environment.

D. METHODOLOGY

The methodology used in this thesis will consist of the following.

- Conduct a literature survey of books, journal articles, and material from the World Wide Web related to the history of pandemic influenza in the Unites States, the current DoD pandemic influenza response initiatives, and the current CDC pandemic influenza response initiatives
- Develop two mathematical models that identify the variables that must be considered to minimize the gap of time between the arrival of vaccine at an LDC and the administration of it to the affected population using only DoD assets for last-mile transportation
- Summarize the results and offer recommendations

II. LITERATURE REVIEW

A. HISTORY OF INFLUENZA PANDEMIC IN THE UNITED STATES

Each year between 5%–20% of the United States population becomes infected with seasonal influenza. Of those infected, an average of 200,000 are hospitalized with infections developed from seasonal influenza, and an average of 36,000 Americans die each year from complications related to seasonal influenza (CDC, 2009). The seasonal influenza that strikes yearly is not considered a pandemic. A pandemic, by definition, is any disease that is virulent enough to cause a global outbreak of serious illness. Pandemic influenza arises when a strain of influenza causes a global outbreak because humans have very little natural immunity to it. Thus, the disease can spread easily from one person to another (Health and Human Services, 2005). Pandemic influenzas are challenging because their strains can mutate—introducing a new strain of influenza to the population for which there is not an existing vaccine. Since 1900, there have been three worldwide pandemic influenza outbreaks and a number of threats that affected the United States (Jones & Tecmire, 2007). These pandemics were a new "A" type virus strain that emerged during the 20th century and spread around the world within one year of being detected (Gurr, 2006).

1. Spanish Influenza

The worst pandemic of the 20th century was the Spanish Influenza of 1918. Worldwide, it caused an estimated 22 million deaths according to the CDC. In the United States, an estimated 675,000 people lost their lives (Health and Human Services, 2005). That is more people than the population of the Navy and Marine Corps combined. The Spanish Influenza was a type "A" (H1N1) strain and caused a panic because it attacked young, healthy individuals—a demographic accounting for half of the reported deaths (Gurr, 2006).

2. Asian Influenza

In 1957–1958, there was a pandemic strain of type "A" (H2N2) called Asian Influenza (Snacken, Kendal, Haaheim & Wood, 1999). This strain originated in China in February and spread to the United States in the summer of 1957. Although not as severe as the Spanish Influenza, it still killed more than 1 million people worldwide and over 70,000 in the United States (CDC, 2009).

3. Hong Kong Influenza

The "Hong Kong Flu" occurred in 1968–1969 and was caused by an "A" (H3N2) type virus (Snacken et al., 1999). It is estimated that 750,000 people worldwide died of the virus, and 34,000 of those deaths occurred in the United States. Both the 1957–1958 and 1968–1969 were known to be caused by viruses containing a combination of genes from a human influenza and an avian influenza virus (Gurr, 2006).

4. Avian Influenza

The Avian Influenza (H5N1) occurred in China, Indonesia, Thailand, Vietnam, and Turkey with over 60 reported deaths in 2003 (Jones & Tecmire, 2007). Although this strain did not reach the United States, there are fears of a return some time in the 21st century.

5. Swine Influenza

The latest pandemic (as of this writing) was the Swine Influenza (H1N1) of 2009. On June 11, 2009, with more than 70 countries reporting cases of the virus, the WHO declared a worldwide pandemic of swine influenza, the first in over 40 years (CDC, 2009). The first illness from the virus originated in Mexico in March, with the first confirmed case in the United States occurring on April 15, 2009. By June 3, 2009, all 50 states (including the District of Columbia and Puerto Rico) reported cases of Swine Influenza. As of June 12, 2009, there were 17,855 cases in the Unites States and 45 deaths.

B. CURRENT DOD PANDEMIC INFLUENZA RESPONSE INITIATIVES

This section focuses on the policies the U.S. Government has in place to handle, contain, and fight a pandemic influenza outbreak. Government policies task the DoD with certain responsibilities. These DoD-specific tasks will be discussed in-depth in this study, with a focus on the transportation and distribution plan of pandemic influenza vaccine.

1. National Strategy for Pandemic Influenza

On November 1, 2005, President George W. Bush approved the *National Strategy for Pandemic Influenza* with the following statement:

> Once again, nature has presented us with a daunting challenge: the possibility of an influenza pandemic. A new strain of influenza virus has been found in birds in Asia, and has shown that it can infect humans. If this virus undergoes further change, it could very well result in the next human pandemic. We have an opportunity to prepare ourselves, our Nation, and our world to fight this potentially devastating outbreak of infectious disease. The *National Strategy for Pandemic Influenza* presents our approach to address the threat of pandemic influenza, whether it results from the strain currently in birds in Asia or another influenza virus. The *Strategy* outlines how we intend to prepare for, detect, and respond to a pandemic. It also outlines the important roles to be played not only by our federal government, but also by the state and local governments, private industry, our international partners, and most importantly individual citizens, including you and your families. While your government will do much to prepare for a pandemic, individual action and individual responsibility are necessary for the success of any measures. Not only should you take action to protect yourself and your families, you should also take action to prevent the spread of influenza if you or anyone in your family becomes ill. Together we will confront this emerging threat, and together, as Americans, we will be prepared to protect our families, our communities, this great Nation, and our world. (Homeland Security Council, 2005, p. i)

An outbreak of pandemic influenza creates a unique situation in that the response involves a number of different agencies that may or may not work together in a normal environment. As with disaster relief efforts, medical care, infrastructure, economic, and security considerations must all be taken into account (Jones & Tecmire, 2007). To establish guidance regarding the amount of coordination involved in reacting to a pandemic in the United States, the government produced an implementation strategy for the *National Strategy for Pandemic Influenza* less than six months after the President's statement.

2. National Strategy for Pandemic Influenza Implementation Plan

In May 2006, President George W. Bush signed the *National Strategy for Pandemic Influenza Implementation Plan* with the following personal remarks:

> In November 1, 2005, I announced the *National Strategy for Pandemic Influenza,* a comprehensive approach to addressing the threat of pandemic influenza. Our strategy outlines how we are preparing for, and how we will detect and respond to, a potential pandemic. Building upon these efforts, the *Implementation Plan (Guide) for the National Strategy for Pandemic Influenza* ensures that our efforts and resources will be brought to bear in a coordinated manner against this threat. The plan describes more than 300 critical actions, many of which have already been initiated, to address the threat of pandemic influenza. Our efforts require the participation of, and coordination by, all levels of government and segments of society. State and local governments must be prepared, and my Administration will work with them to provide the necessary guidance in order to best protect their citizens. No less important will be the actions of individual citizens, whose participation is necessary to the success of these efforts. Our Nation will face this global threat united in purpose and united in action in order to best protect our families, our communities, our Nation, and our world from the threat of pandemic influenza. (Homeland Security Council, 2006, p. ii)

The implementation plan provides a common set of tasks and responsibilities to all the agencies involved. It also discusses a pandemic threat and summarizes the planning considerations that need to be addressed in the event of such an emergency. The plan also outlines the expectations that affected populations have both in the United States and abroad (Jones & Tecmire, 2007).

a. Implementation Plan Outline

The implementation guide for the *National Strategy for Pandemic Influenza* further clarifies the roles and responsibilities of governmental and non-governmental entities. The plan addresses the following topics.

- U.S. Government Planning and Response (Chapters 2 and 3)
- International Efforts and Transportation and Borders (Chapters 4 and 5)
- Protecting Human Health (Chapter 6)
- Protecting Animal Health (Chapter 7)
- Law Enforcement, Public Safety, and Security (Chapter 8)
- Institutional Considerations (Chapter 9)

The implementation plan represents a comprehensive effort by the federal government to identify the critical steps that must be taken immediately and over the coming months and years to address the threat of an influenza pandemic. It assigns specific responsibilities to federal departments and agencies, and includes measures of progress and timelines for implementation to ensure that the federal government meets its preparedness objectives (Homeland Security Council, 2006, pp. vii–viii).

b. DoD Transportation Responsibilities

The first priority of DoD support, in the event of a pandemic, will be to provide sufficient personnel, equipment, facilities, materials, and pharmaceuticals to care for DoD military and civilian personnel, dependents, and beneficiaries to protect and preserve the operational effectiveness of our forces throughout the globe (Homeland Security Council, 2006). In Chapter 6 of the *Implementation Guide,* the DoD has mandated the following transportation responsibilities.

- Pillar One: Preparedness and Communication (6.1.6.3):

  DoD, as part of its departmental implementation plan, shall conduct a medical requirements gap analysis and procure necessary material to enhance military health system sure capacity within 18 months. Measure of performance: gap analysis completed and necessary material procured. (Homeland Security Council, 2006, p. 119)

- Pillar One: Preparedness and Communication (6.1.7.4):

  DoD shall establish stockpiles of vaccine against H5N1 and other influenza subtypes determined to represent a pandemic threat adequate to immunize approximately 1.35 million persons for military use within 18 months of availability. Measure of performance: sufficient vaccine against each influenza virus determined to represent a pandemic threat in DoD stockpile to vaccinate 1.35 million persons. (2006, p. 120)

- Pillar One: Preparedness and Communication (6.1.13.4):

  DoD, in coordination with Health and Human Services and Veterans Affairs, and in collaboration with state, local and tribal governments and private sector partners, shall assist in the development of distribution plans for medical countermeasure stockpiles to ensure that delivery and distribution algorithms have been planned. Measure of performance: distribution plans developed. (2006, p. 122)

- Pillar One: Preparedness and Communication (6.1.13.8):

  DoD shall supply military units and posts, installations, bases, and stations with vaccine and antiviral medications according to the schedule of priorities listed in the DoD pandemic influenza policy and planning guidance, within 18 months. Measure of performance: vaccine and antiviral medications procured; DoD policy guidance developed on the use and release of vaccine and antiviral medications; and worldwide distribution drill completed. (2006, p. 123)

Given the highly distributed nature of a pandemic, the need to deliver pandemic influenza vaccine quickly presents significant logistical challenges, many of which may be unresolved. It is necessary to develop and exercise pandemic influenza distribution plans in each of the states and territories, as well as to construct public-private partnerships to ensure the seamless, efficient, and timely distribution of these countermeasures (Homeland Security Council, 2006). It is evident that managing the distribution of vaccine during a pandemic will require the highest amount of coordination between public- and private-sector entities, as well as between local, state, and federal agencies. If the DoD is attempting to transport vaccine on a route that has been closed by a local authority, it will increase the amount of time for countermeasure distribution. Facing these types of challenges, the DoD drafted an implementation plan to address these issues specifically regarding distribution and transportation of vaccine.

3. DoD Implementation Plan for Pandemic Influenza

Department of Defense Implementation Plan for Pandemic Influenza was issued in August of 2006 to provide planning and implementation guidance to the Office of the Secretary of Defense, COCOMs, Military Departments, and DoD agencies. In the document's conclusion, the Assistant Secretary of Defense for Homeland Defense states: "It is imperative that DoD develop policies and plans that provide for an active, layered defense and coordinate with our federal partners to ensure that governments at all levels domestically and abroad are prepared to face a pandemic threat" (DoD, 2006).

The Secretary of Defense's principal responsibility in responding to a pandemic is to protect U.S. interests at home and abroad. This DoD-specific plan sets forth DoD guidance and addresses key policy issues for pandemic influenza planning. This guidance will enable the Combatant Commander, Military Services, and DoD agencies to develop plans to prepare for, detect, respond to, and contain the effects of a pandemic on military forces, DoD civilians, DoD contractors, dependents, and beneficiaries (DoD, 2006).

a. Transportation Responsibilities

Annex (A) of the *Department of Defense Implementation Plan for Pandemic Influenza* lists all national plan action numbers assigned to the DoD in the *Implementation Guide*. There are 114 total tasks, 31 of which are to be primarily enacted by the DoD. Of the four specific transportation tasks the DoD was tasked within the National *Implementation Plan*, the DoD was mandated as the lead agency on three of the four tasks. These tasks are currently in the planning stages, and there is nothing in writing as to how these tasks are to be accomplished in the event of a pandemic influenza outbreak (Jones & Tecmire, 2007).

b. Combatant Commander's Role

Although the *Department of Defense Implementation Plan for Pandemic Influenza* was originated from the Office of the Secretary of Defense, it is merely a policy tool that is intended to guide the planning process for the Joint Staff and, ultimately, each

Combatant Command (COCOM) (DoD, 2006). As operational commanders, the DoD's COCOMs are an essential part of the Department's pandemic influenza planning. There are currently nine COCOMs—five with geographic responsibilities and four with functional responsibilities. To ensure proper pandemic planning, it is paramount that COCOMs have lines of communication that stretch well beyond operational responsibilities. In a recent Government Accountability Office (GAO) report, numerous challenges were identified that hindered the planning and preparedness efforts of COCOMs (GAO, 2007). Of specific interest in this thesis is the GAO finding that some of the biggest planning obstacles were caused by limited detailed guidance to the COCOMs from other federal agencies on the support expected from the DoD, lack of control over the DoD's stockpile of antivirals, and reliance on military services for medical material from other federal agencies (GAO, 2007).

Planning officials from three COCOMs and two service subcomponents recently stated, "Planning for the COCOMs to provide support at the last minute could lead to a less effective and less efficient use of resources" (GAO, 2007, p. 8). Although it is difficult to plan for an influenza pandemic and to mitigate the effects of factors that are beyond their control, the COCOMs' ability to protect their personnel and perform their missions during an influenza pandemic may be minimal. The GAO gives the following example: if a nation decides to close its borders at the start of a pandemic, the COCOMs and the installations for which they are responsible may not be able to obtain needed supplies, such as vaccines and antivirals (GAO, 2007).

c. Transportation Issues

Planning officials from eight of the nine COCOMs expressed concern that their headquarters are tenants of military services' installations and, therefore, are reliant on the military services to distribute medical material and other supplies (GAO, 2007). This factor has hindered the COCOMs' ability to address fully how their headquarters will receive medical material and other supplies during an influenza pandemic. Medical and planning officials on two COCOMs' staffs expressed concern with the variance among the military services' health-related policies and priorities. For example, each military service has a different doctrine or policy on pandemic influenza-related health issues, such as the distribution of vaccines, antivirals, and other drugs (GAO, 2007). Although guidance from the Assistant Secretary of Defense for Health Affairs (ASD HA) is the same for all of the military services, it is applied differently in each service. In itself, this variation may be appropriate. However, certain differences in application of the guidance could have adverse consequences. For example, medical and planning officials from four of the COCOMs' staffs noted that each separate military service would determine how vaccines and antivirals would be used because these supplies would be provided through the military services themselves (GAO, 2007). This variance in policy implementation could lead to different preparedness levels and could limit the operational control that COCOMs would have during a pandemic, which would directly impair their ability to carry out their missions.

4. DoD Response Initiatives Summary

In response to the *National Strategy for Pandemic Influenza Implementation Plan,* the DoD identified the need to provide guidance to the COCOMs with regard to what their respective responsibilities would be in the event of a pandemic influenza outbreak. Specific challenges were discussed concerning the transportation of vaccine and the COCOMs' lack of confidence in the fact proper coordination was being made between those that make the policies in Washington and those who plan and execute those policies on the front lines.

5. CDC Pandemic Influenza Response Initiatives

As the *National Strategy for Pandemic Influenza* was released, the Department of Health and Human Services (HHS) also released the *Health and Human Services Pandemic Influenza Plan* in November of 2005. In it, the HHS outlines roles and responsibilities of the agencies in the Department in preparation for carrying out the tasks mandated in the *National Strategy for Pandemic Influenza Implementation Plan.* In the introduction, Michael Leavitt, the Secretary of HHS at the time, discussed the importance of HHS's mission by issuing the following statement:

> This *Health and Human Services Pandemic Influenza Plan* provides a blueprint from which to prepare for the challenges that lie ahead of us. Being prepared and responding effectively involves everyone: individuals, communities, businesses, States, Federal agencies, international countries and organizations. Here at home, we can use this *Plan* to create a seamless preparedness network where we are all working together for the benefit of the American people. (Health and Human Services, 2005, p. 1)

The *Plan* assigns 16 tasks to the CDC, the most tasks assigned to any one agency under HHS. These tasks include the following.

1. Conducts and supports clinical and virological influenza surveillance
2. Monitors pandemic health impacts
3. Implements travel-related and community containment measures as necessary to prevent the introduction, transmission, and spread of pandemic disease from foreign countries into the US, from state to state or in the event of inadequate local control
4. Coordinates pandemic response activities with state, local and tribal public health agencies
5. Investigates epidemiology and clinical characteristics of pandemic disease
6. Assists in vaccination program implementation and in monitoring and investigating vaccine-adverse events
7. Assesses vaccine effectiveness in population-based studies
8. Coordinates antiviral and other drug delivery from the Strategic National Stockpile
9. Monitors antiviral drug use, effectiveness, safety, and resistance
10. Monitors the implementation/effectiveness of protective public health measures
11. Recommends and evaluates community measures to prevent and control disease
12. Makes recommendations on diagnosis and management of influenza illness

13. Makes recommendations on appropriate infection-control recommendations
14. Communicates with state and local health departments and other public health partners
15. Communicates information on pandemic health impacts as directed by the ASPA
16. Maintains close communication with drug and vaccine manufacturers (Health and Human Services, 2005, p. 28)

Task number 8 is the responsibility of coordinating the delivery of antivirals and other drugs from the National Strategic Stockpile. It is this task that will cause a competition for resources should the DoD contract commercial, private-sector delivery companies to deliver vaccine.

THIS PAGE INTENTIONALLY LEFT BLANK

III. INSTALLATION DESCRIPTIONS

A. INTRODUCTION

This chapter will discuss planning factors that must be identified when policy-makers are determining how vaccine will be delivered and administered to a given population. Since there is no recent historical data to draw from regarding the mass vaccination of a military population in the event of pandemic influenza, many of the assumptions and planning factors used are based on the respective installation's procedures for ordering and administering seasonal influenza vaccine (which is given to the enrolled population at each given health clinic). According to LtCol Wayne Hachey, the Director of Preventative Medical Surveillance at the Department of Health Affairs, the healthcare services company McKesson has been contracted to deliver the vaccine for the H1N1 Swine Flu campaign from the manufacturer. The vaccine for all active duty military will be delivered to the respective installation health clinics based on the number of their active duty populations. The vaccine for the dependents will be delivered to the CDC in each state to be distributed to local public health clinics (W. Hachey, personal communication, August 25, 2009). According to Donald Neil, Director of Prevention and Intervention at Naval Hospital Camp Lejeune, this creates an environment of potential double-ordering of vaccine because neither the military health clinics nor the local public health clinics knows where dependents will receive their vaccination.

The characteristics of each of the seven installations described in this chapter are the following.

- Population of active duty, dependents, and DoD civilian employees requiring vaccination
- Number of assets required to deliver a specific amount of vaccine for each installation
- Distance from the distribution hub (airport) to the MTF where vaccine will be administered
- Transportation time from the distribution hub to the MTF

- Number of medical workers that will be working per day to administer vaccinations
- Number of hours per day vaccine will be administered

Planning factors that are constant between all bases are as follows.

- On average, a medical worker can vaccinate between 30 and 60 patients in one hour (Camp Lejeune Naval Hospital, 2005)
- An MTVR travels an average of 30mph on local roads to deliver vaccine (FAS, 2007)
- A CH-53 travels an average of 150mph by air to deliver vaccine (FAS, 2007)
- Eight standard warehouse pallets can be transported on an MTVR, equaling 64,512 doses of vaccine per MTVR (Oshkosh, 2008)
- Six standard warehouse pallets can be transported inside a CH-53, equaling 48,384 doses of vaccine per helicopter (FAS, 2007)

Figure 2. (Left) Medium Tactical Vehicle Replacement (MTVR) (Right) CH-53 Sea Knight

B. MARINE CORPS LOGISTICS BASE (MCLB) ALBANY, GA

Located in the southwest corner of the state of Georgia, MCLB Albany is the southernmost installation in the scope of the model. According to Shannon Thomas, the director of immunizations at the Branch Medical Clinic Albany, the clinic serves approximately 1,500 active duty, dependents, and civilians enrolled at the facility. Naval Hospital Jacksonville orders the vaccine from the manufacturers. When the vaccine arrives at Naval Hospital Jacksonville, it is then delivered to the Branch Medical Clinic Albany (S. Thomas, personal communication, August 26, 2009). The route, distance, and travel times from Naval Hospital Jacksonville to the Branch Medical Clinic Albany are depicted in Figure 3.

Figure 3. Route from Naval Hospital Jacksonville to Branch Medical Clinic Albany (After: Google Maps)

The distance from Naval Hospital Jacksonville to the health clinic is 213 miles. An MTVR traveling the route going an average of 30 mph will take approximately seven hours to deliver the vaccine. A CH-53 flying an average of 150 mph would take one hour and 25 minutes to transport the vaccine. However, because there are no CH-53 helicopters that are organic to MCLB Albany or the surrounding area, the MTVR would be the most likely mode of transportation. It would take only one MTVR or CH-53 helicopter to deliver the amount of vaccine required for the population the Albany clinic serves. In the event of a pandemic, the health clinic estimates it would have one medical staff for every 50 patients, administering vaccine for 10 hours each day (S. Thomas, personal communication, August 26, 2009).

C. MARINE CORPS RECRUIT DEPOT (MCRD) PARRIS ISLAND, SC

The population at MCRD Parris Island is different in that it includes all prospective recruits that are undergoing training. The Branch Medical Clinic (BMC) aboard MCRD Parris Island and Beaufort Naval Hospital would be used as a point of dispensing (POD) and would order vaccine in preparation for inoculating 10,700 enrolled active duty, dependents, and civilians. In the event that a mass vaccination is necessary, the active duty patients would receive vaccination at the BMC aboard MCRD Parris, while the dependents and any enrolled civilian employees would have the choice of being be vaccinated at the Beaufort Naval Hospital (located in the city of Beaufort, SC, outside the base) or at the local public health clinic. The vaccine that is ordered is flown into the Savannah International Airport in Georgia. The routes, distances, and travel times from the Savannah International Airport to both the Naval Hospital and MCRD Parris Island are depicted in Figures 4 and 5.

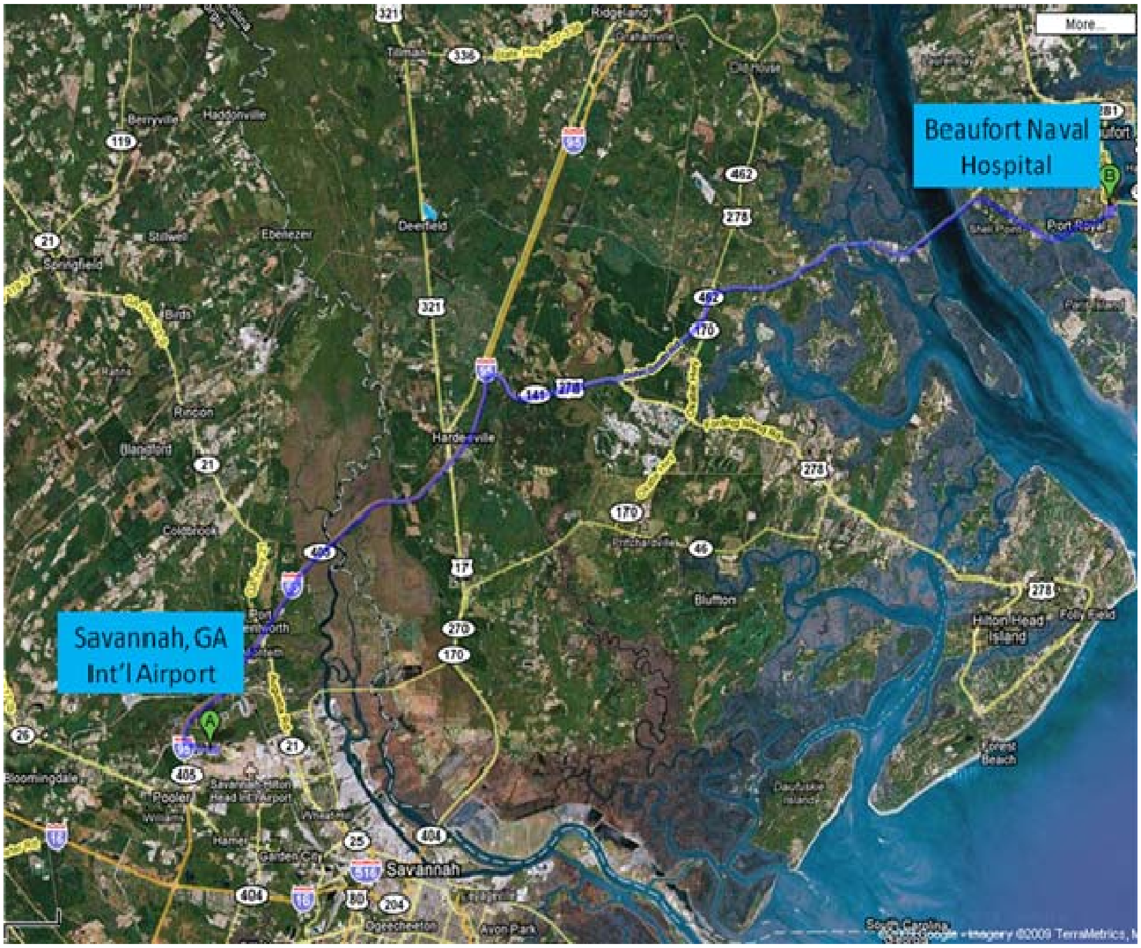


Figure 4. Route from Savannah International Airport to Beaufort Naval Hospital (After: Google Maps)

The distance from the airport to the Beaufort Naval Hospital is 43.9 miles. An MTVR traveling the route going an average of 30 mph will take 88 minutes to deliver the vaccine. A CH-53 flying an average of 150 mph will take 17.6 minutes to deliver the vaccine. It would take only one MTVR or CH-53 helicopter to deliver the amount of vaccine required for the population.

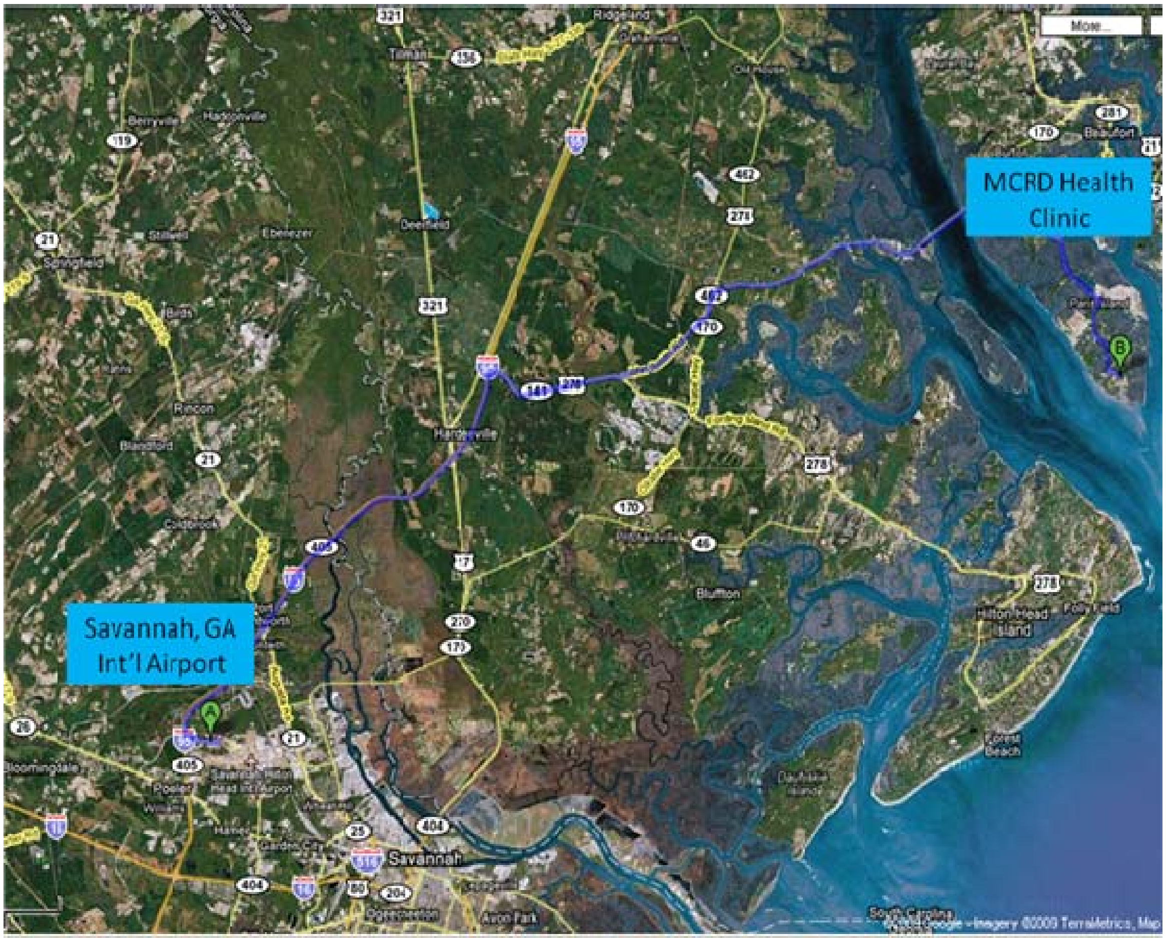


Figure 5. Route from Savannah International Airport to MCRD Parris Island Health Clinic (After: Google Maps)

The distance from the airport to the MCRD Parris Island Health Clinic is 47.1 miles. An MTVR traveling the route going an average of 30 mph will take 95 minutes to deliver the vaccine. A CH-53 flying an average of 150 mph will take 19 minutes to deliver the vaccine. It would take only one MTVR or CH-53 helicopter to deliver the amount of vaccine required for the population.

D. MARINE CORPS AIR STATION (MCAS) BEAUFORT, SC

As previously mentioned, MCAS Beaufort is located in the same city as MCRD Parris Island and has 12,338 active duty, dependents, and civilian employees enrolled at its health clinic. Like MCRD, the active duty patients stationed at MCAS will receive their vaccination at the BMC aboard the MCAS, while the dependents and any enrolled civilian employees would be inoculated at Beaufort Hospital or the local public health clinic. The close proximity of the locations allows the vaccine to be delivered to the Savannah International Airport. The route and planning factors for the Beaufort Naval Hospital are the same. The route, distance, and travel times from the Savannah International Airport to MCAS Beaufort are depicted in Figure 6.

Figure 6. Route from Savannah International Airport to MCAS Health Clinic (After: Google Maps)

The distance from the airport to the MCAS Beaufort Health Clinic is 45 miles. An MTVR traveling the route going an average of 30 mph will take 90 minutes to deliver the vaccine. A CH-53 flying an average of 150 mph will take 18 minutes to deliver the vaccine. It would take only one MTVR or CH-53 helicopter to deliver the amount of vaccine required for the population.

E. MARINE CORPS BASE (MCB) CAMP LEJEUNE, NC

MCB Camp Lejeune is the largest in population of the seven installations. The Naval Hospital aboard MCB Camp Lejeune handles all of the dependents and enrolled civilian employees from both MCB Camp Lejeune and MCAS New River (D. Neil, personal communication, August 27, 2009). The active duty patients from the two bases are vaccinated at their respective BMCs, but the Naval Hospital still coordinates the ordering of the proper amount of vaccine for both bases—which totals approximately 124,000 patients. However, the amount of vaccine to order is dynamic because dependents can be vaccinated at the MCB Camp Lejeune Naval Hospital or the local public health clinic (D. Neil, personal communication, August 27, 2009). The vaccine is flown into the Wilmington International Airport. Both MTVR and CH-53 assets are available to deliver vaccine from the Wilmington International Airport. However, the assets that would carry out the delivery mission would need to be identified prior to a pandemic outbreak. The route, distance, and travel times from the Wilmington, NC, Airport to MCB Camp Lejeune Naval Hospital are depicted in Figure 7.

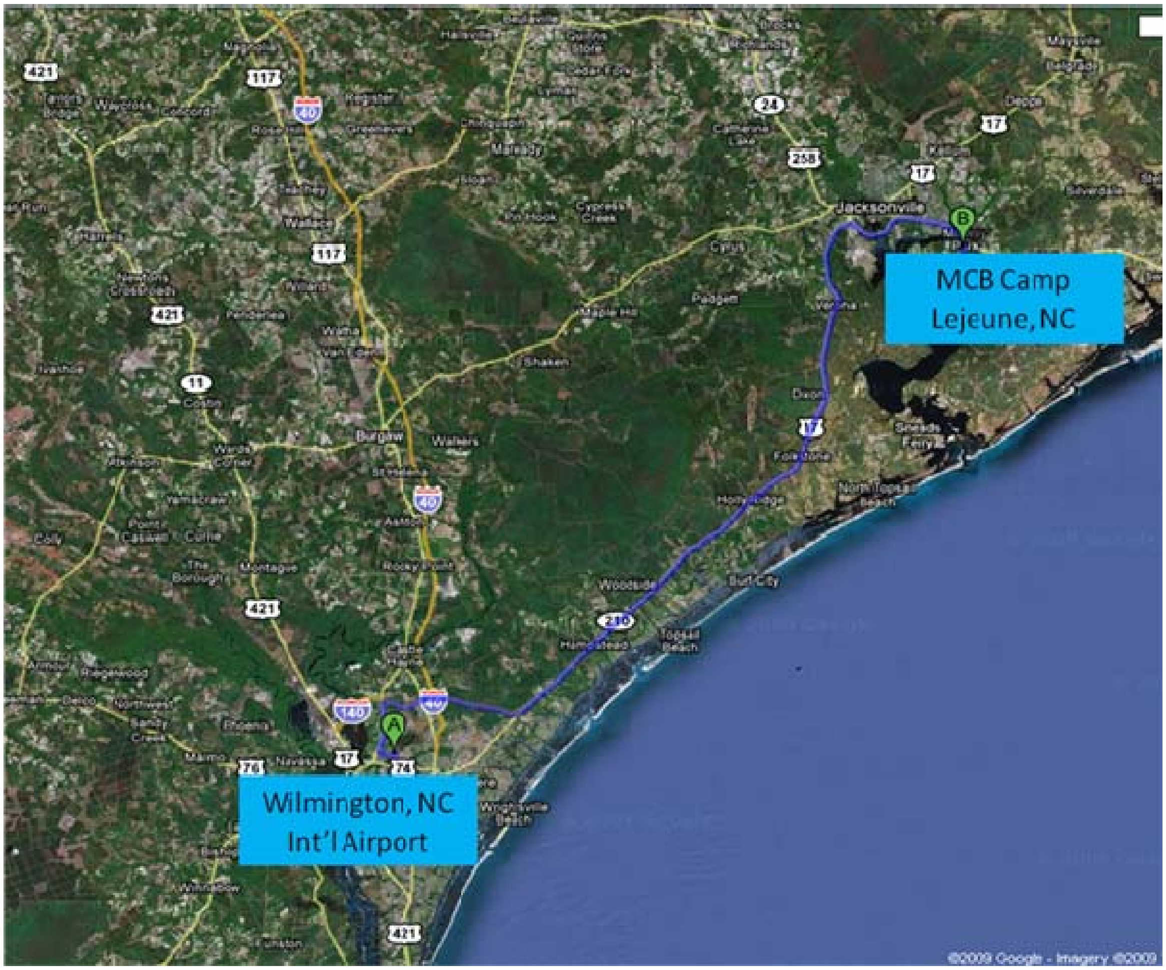


Figure 7. Route from Wilmington International Airport to MCB Camp Lejeune (After: Google Maps)

The distance from the airport to the MCB Camp Lejeune Naval Hospital is 59.2 miles. An MTVR traveling the route going an average of 30 mph will take approximately two hours to deliver the vaccine. A CH-53 flying an average of 150 mph will take 23 minutes to deliver the vaccine. It would take two MTVRs or CH-53 helicopters to deliver the amount of vaccine required for the population.

The pre-pandemic response plan provided by the Naval Hospital Camp Lejeune directs that in the event of a pandemic, MCB Camp Lejeune would have five vaccination centers (VC) open around the base, each one containing eight vaccination stations (VS). Every VS would be staffed with two vaccine-trained medical staff at a time. The medical staff will be scheduled in 8-hour shifts. Thirty-two vaccine trained medical staff will be required at each VC in order to provide vaccinations for a period of 16 hours per day. Estimating that they can complete between 30 and 60 vaccinations per hour, MCB Camp Lejeune estimates it could vaccinate the 96,445 patients in five days (Camp Lejeune Naval Hospital, 2009).

F. MCAS NEW RIVER, NC

The population at MCAS New River includes 9,249 active duty, dependents, and civilian employees stationed there. The vaccine for the active duty patients aboard MCAS New River is also flown into the Wilmington International Airport. The route, distance, and travel times from the Wilmington, NC, Airport to MCAS New River Health Clinic are depicted in Figure 8.

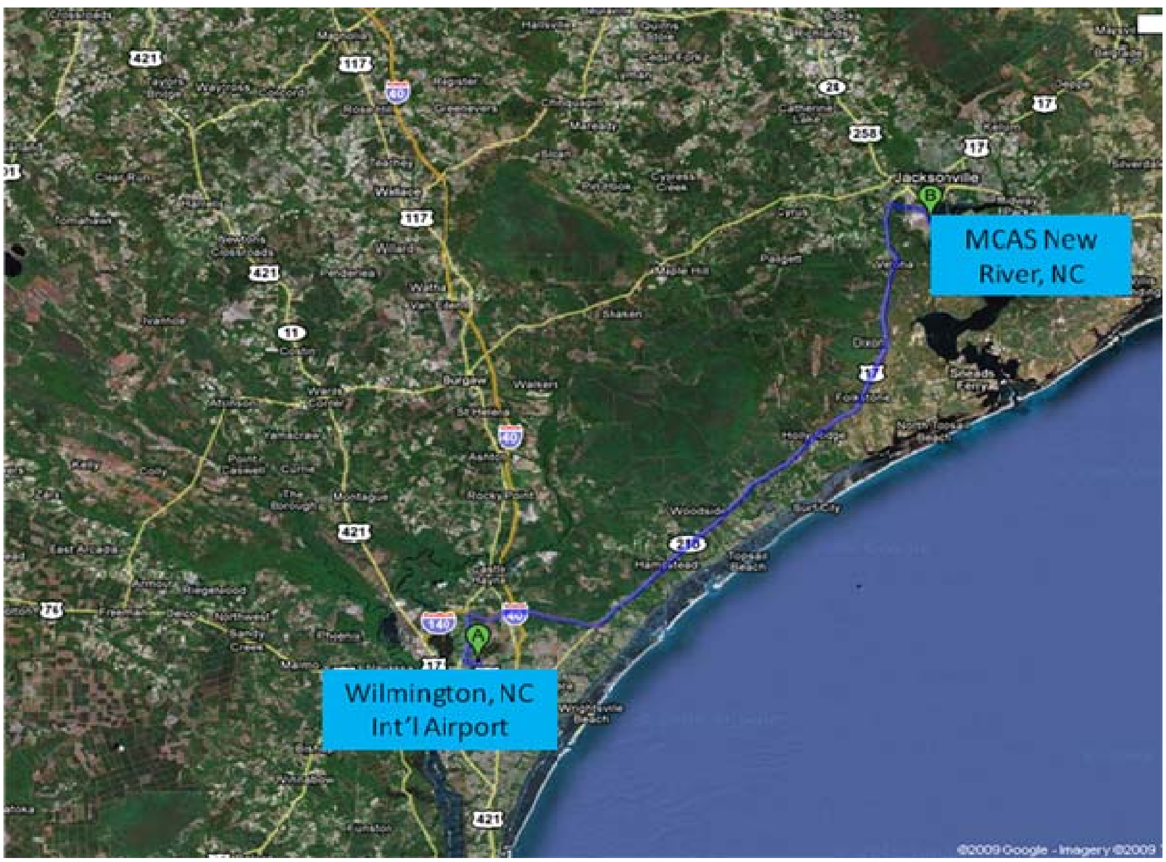


Figure 8. Route from Wilmington International Airport to MCAS New River Health Clinic (After: Google Maps)

The distance from the airport to the MCAS New River Health Clinic is 52.7 miles. An MTVR traveling the route going an average of 30 mph will take approximately one hour and 45 minutes to deliver the vaccine. A CH-53 flying an average of 150 mph will take 21 minutes to deliver the vaccine. It would take only one MTVR or CH-53 helicopter to deliver the amount of vaccine required for the population. In the event of a pandemic, MCAS New River Health Clinic would send medical staff to assist filling positions at the VCs coordinated by MCB Camp Lejeune Naval Hospital (D. Neil, personal communication, August 27, 2009).

G. MCAS CHERRY POINT, NC

The population at MCAS Cherry Point includes 40,645 active duty, dependents, and civilian employees stationed there. The vaccine for the active duty patients aboard MCAS Cherry Point is also flown into the Wilmington International Airport. The route, distance, and travel times from the Wilmington, NC, Airport to MCAS Cherry Point Health Clinic are depicted in Figure 9.

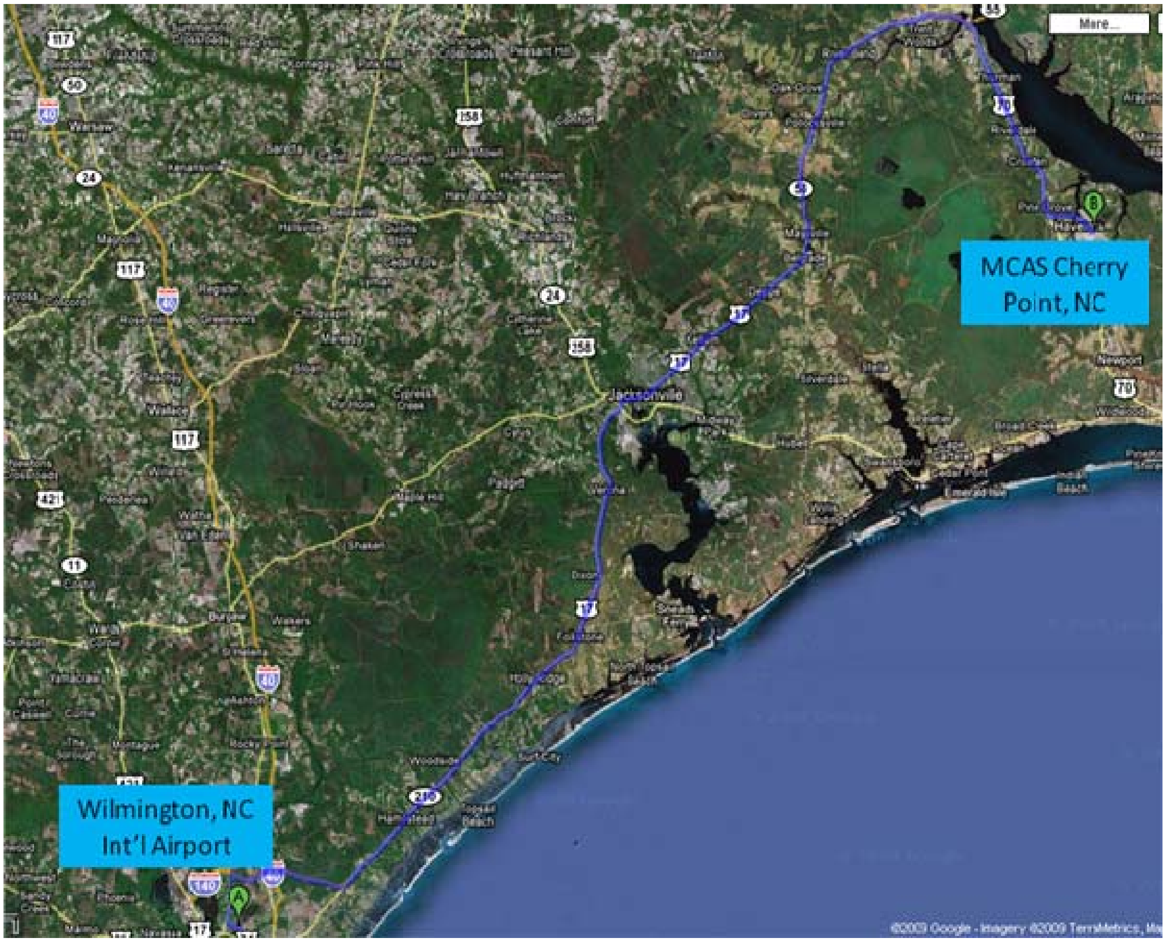


Figure 9. Route from Wilmington International Airport to MCAS Cherry Point (After: Google Maps)

The distance from the airport to the MCAS Cherry Point Health Clinic is 107 miles. An MTVR traveling the route going an average of 30 mph will take approximately 3.5 hours to deliver the vaccine. A CH-53 flying an average of 150 mph will take 42 minutes to deliver the vaccine. It would take only one MTVR or CH-53 helicopter to deliver the amount of vaccine required for the population.

H. MCB QUANTICO, VA

The Naval Health clinic at MCB Quantico has 20,775 active duty, dependents, and civilian employees enrolled (E. Hartigan, personal communication, August 21, 2009). Vaccine for seasonal flu is ordered from Navy Medical Logistics Command

(NavMedLogCom) and is flown in to Andrews Air Force Base (AFB). The plan for a pandemic is received from the Department of Homeland Security, which will then be fed through NavMedLogCom or delivered directly to the command (E. Hartigan, personal communication, August 21, 2009). Since MCB Quantico is in restricted air space, the use of the MTVR will be required for ground transport of the vaccine from Andrews AFB. The route, distance and travel time from Andrews AFB to Quantico Naval Health Clinic are depicted in Figure 10.

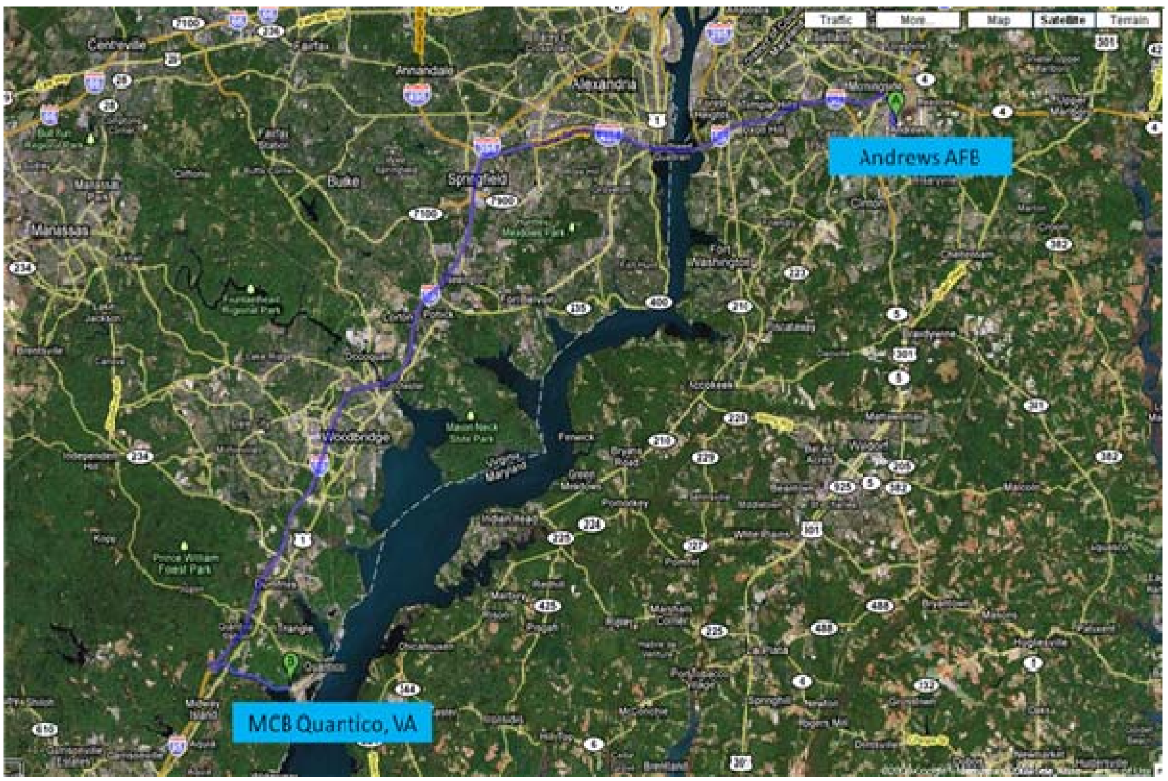


Figure 10. Route from Andrews AFB to Quantico Naval Health Clinic (After: Google Maps)

The distance from the airport to the MCB Quantico Naval Health Clinic is 43.6 miles. An MTVR traveling the route going an average of 30 mph will take approximately one hour, twenty-seven minutes to deliver the vaccine. It would take only one MTVR to deliver the amount of vaccine required for the population.

According to CDR Carol Hurley, Director Public Health Services at the Quantico Naval Health Clinic (personal communication, August 21, 2009), in the event of a pandemic, additional medical staff and vaccine would be needed in order to get the entire enrolled population vaccinated.

I. CHAPTER SUMMARY

This chapter identified the variables that must be considered in setting up a distribution model for pandemic influenza vaccine. Each site is different and has its own set of variables to incorporate into the planning process. As is evident from the travel distances and vaccine amounts, the limiting factor in transporting the vaccine is not the amount of assets available but the planning that is required to identify—prior to a pandemic outbreak—which assets will be assigned to carry out the delivery mission. Each site will handle administration of the vaccine to the population differently based on staffing levels and the demographics of the patients. Table 1 contains an installation description matrix is depicted below that can be populated with data applicable to any affected area.

The following chapter will incorporate these variables into a model that planners can apply to any region by inserting the data specific to the situation.

Installation	Population	Nearest Hub (Airport)	Distance to Hub	Transportation Assets Required	Transportation Assets Available	Transportation Time (Ground)	Transportation Time (Air)	Number of Medical Staff Available	Hours/Day for Vaccination
MCLB Albany	1,500	Naval Hospital Jacksonville	213 mi	1 MTVR or 1 CH-53	1 MTVR	7 hour	N/A	1 per 50 patients	10
Beaufort Naval Hospital	Dependent	Savannah, GA	43.9 mi	1 MTVR or 1 CH-53	1 MTVR or 1 CH-53	88 minutes	17 minutes		
MCRD Parris Island	10,700	Savannah, GA	47.1 mi	1 MTVR or 1 CH-53	1 MTVR or 1 CH-53	95 minutes	19 minutes		
MCAS Beaufort	12,338	Savannah, GA	45 mi	1 MTVR or 1 CH-53	1 MTVR or 1 CH-53	90 minutes	18 minutes		
MCB Camp Lejeune	124,000	Wilmington, NC	59.2 mi	1 MTVR or 1 CH-53	1 MTVR or 1 CH-53	120 minutes	23 minutes	32	16
MCAS New River	9,249	Wilmington, NC	52.7 mi	1 MTVR or 1 CH-53	1 MTVR or 1 CH-53	105 minutes	21 minutes	32	16
MCAS Cherry Point	40,645	Wilmington, NC	107 mi	1 MTVR or 1 CH-53	1 MTVR or 1 CH-53	210 minutes	42 minutes		
MCB Quantico	20,775	Andrews AFB	43.6 mi	1 MTVR or 1 CH-53	1 MTVR	87 minutes	N/A		

Table 1. Installation Description Matrix

THIS PAGE INTENTIONALLY LEFT BLANK

IV. DISTRIBUTION MODEL AND RESULTS

A. INTRODUCTION

This chapter will describe two mathematical models that can be applied to an affected area in order minimize the amount of time to deliver and administer vaccine in the event of a pandemic influenza outbreak. There are specific variables that must be identified in order to develop a distribution system for vaccine. After describing the two models, the results of a delivery simulation run with the Arena 10.0 program will be analyzed.

B. TRANSPORTATION MODEL

In order to develop a distribution system for vaccine, certain characteristics must be known about the affected area. The number of individuals in the affected area requiring vaccination will determine how much vaccine will need to be transported. The amount of vaccine to be delivered will give planners a factor with which to calculate the number of transportation assets that will need to be available. Because doses of vaccine are small in volume, it does not require a large amount or transportation for delivery, approximately one Medium Tactical Vehicle Replacement (MTVR) or one CH-53 helicopter per installation is required to transport enough vaccine for the base's population. Conflict in planning arises when there are no assets identified to carry out the delivery mission in the event of a pandemic.

Once the mode of transportation is identified, the distance between the distribution hub and the MTF must be measured. This will allow planners to calculate the time that the delivery of vaccine to the MTF will take.

A transportation model to minimize delivery time to the bases discussed in Chapter III is illustrated below.

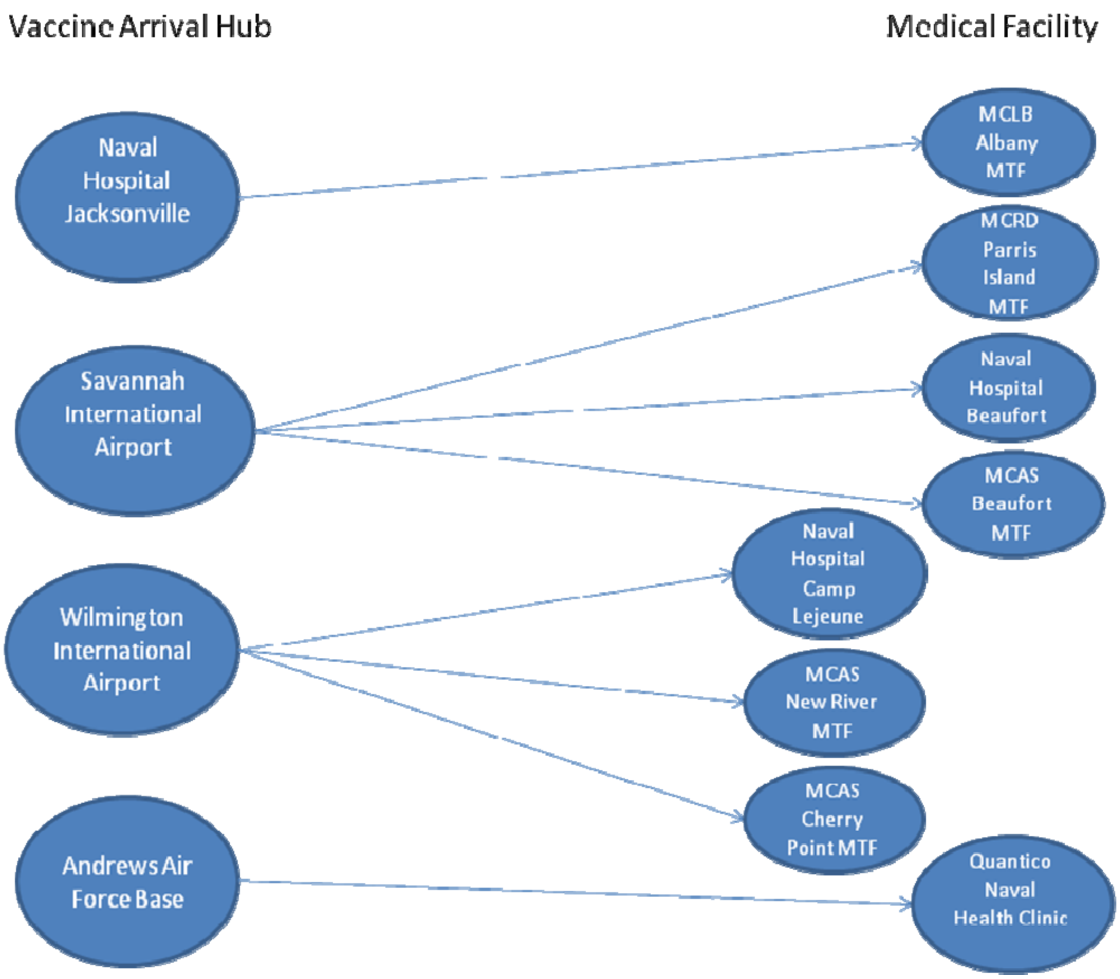


Figure 11. Transportation Model

1. Variables

Tij= Time for vaccine to travel from hub (i) to MTF (j) by MTVR
Hij= Time for vaccine to travel from hub (i) to MTF (j) by CH-53

Hubs (Airports):	MTFs
1= Naval Hospital Jacksonville, FL	1= MCLB Albany Branch Medical Clinic
2= Savannah International Airport	2= Naval Hospital Beaufort
3= Wilmington International Airport	3= MCRD Parris Island MTF
4= Andrews Air Force Base	4= MCAS Beaufort MTF
	5= Naval Hospital Camp Lejeune
	6= MCAS New River MTF
	7= MCAS Cherry Point MTF
	8= Quantico Naval Health Clinic

2. Decision Variables

T11= Time in minutes for all vaccine to travel from Naval Hospital Jacksonville to MCLB Albany Branch Medical Clinic by MTVR

T22= Time in minutes for all vaccine to travel from Savannah International Airport to Naval Hospital Beaufort by MTVR

T23= Time in minutes for all vaccine to travel from Savannah International Airport to MCRD Parris Island MTF by MTVR

T24= Time in minutes for all vaccine to travel from Savannah International Airport to MCAS Beaufort MTF by MTVR

T35= Time in minutes for all vaccine to travel from Wilmington International Airport to Naval Hospital Camp Lejeune by MTVR

T36= Time in minutes for all vaccine to travel from Wilmington International Airport to MCAS New River MTF by MTVR

T37= Time in minutes for all vaccine to travel from Wilmington International Airport to MCAS Cherry Point MTF by MTVR

T48= Time in minutes for all vaccine to travel from Andrews Air Force Base to Quantico Naval Health Clinic by MTVR

H11= Time in minutes for all vaccine to travel from Naval Hospital Jacksonville to MCLB Albany Branch Medical Clinic by CH-53

H22= Time in minutes for all vaccine to travel from Savannah International Airport to Naval Hospital Beaufort by CH-53

H23= Time in minutes for all vaccine to travel from Savannah International Airport to MCRD Parris Island MTF by CH-53

H24= Time in minutes for all vaccine to travel from Savannah International Airport to MCAS Beaufort MTF by CH-53

H35= Time in minutes for all vaccine to travel from Wilmington International Airport to Naval Hospital Camp Lejeune by CH-53

H36= Time in minutes for all vaccine to travel from Wilmington International Airport to MCAS New River MTF by CH-53

H37= Time in minutes for all vaccine to travel from Wilmington International Airport to MCAS Cherry Point MTF by CH-53

H48= Time in minutes for all vaccine to travel from Andrews Air Force Base to Quantico Naval Health Clinic by CH-53

3. Objective Function

Minimize=
T11+T22+T23+T24+T35+T36+T37+T48+H11+H22+H23+H24+H35+H36+H37+H48

4. Constraints

- T11,T22,T23,T24,T35,T36,T37,T48,H11,H22,H23,H24,H35,H36,H37,H48 are binary.
- All decision variables non-negative

The model above was run in the Solver add-in for Microsoft Excel and imposing only the constraints above intuitively yielded results that had a value of "1" for using CH-53 assets for delivery to each base. The fact that the time for the vaccine to travel by CH-53 is less than the time for the vaccine to travel by MTVR does not need a model to be identified. However, additional constraints can be added to this base model depending on various environments that require a vaccine distribution system using only military assets. For instance, any types of available transportation can be substituted for the MTVR and CH-53. The availability of assets in certain areas will also add to constraints placed on the model. If vaccine is being flown into one airport to be delivered to multiple MTFs in the region, as is the case for the three North Carolina bases, a situation could arise where there is a limited amount of available rotary wing assets due to operational tempo. Instead of using only rotary wing assets to make multiple trips between MTFs, a combination of assets would minimize delivery time by using limited rotary wing assets to deliver to the farthest MTF while utilizing trucks to deliver to the MTFs that are closer to the airport.

C. VACCINATION MODEL

When identifying variables for a vaccine administration model, it is crucial to recognize again the fact that each situation is unique and one rule often does not apply to multiple MTFs. Key variables in determining the amount of time it will take to vaccinate a given population are the following.

- The number of people that must be vaccinated
- The number of medical staff at the MTF that are trained in administering vaccinations
- The number of vaccinations that can be given in one hour
- The number of hours per day that vaccinations will be given
- The estimate of how many dependents or civilian employees enrolled at the base MTF will elect to get vaccinated at the local public health clinic

The last variable in this list is the unknown that makes the amount of vaccine to order a guessing game. There is no mandate on where dependents receive their vaccine in the event of a pandemic, so planners are forced to plan for the entire enrolled population, which often leads to inflated order amounts from both the military MTFs and the local public health clinics (D. Neil, personal communication, August 27, 2009).

As discussed in Chapter III, each MTF has its own way of determining how many medical staff will be administering vaccine should a mass vaccination have to be completed. Facilities have either a standard number of medical staff, with the ability to train additional staff if the need arises, or they use a planning factor such as one medical staff per every 50 patients that must be vaccinated. Multiplying the number of hours that the MTF will administer vaccine each day by the number of medical staff that an MTF has working each day will determine the capacity that each MTF will have per day for vaccinations. This capacity when divided by the average amount of time it takes to vaccinate one individual will determine the minimum amount of time it will take to vaccinate the installation's population. The average amount of time it takes to vaccinate one individual will vary depending on the type of pandemic influenza vaccine that is developed: injected vaccine, inhalable, etc. For the purposes of this model, the planning factor of two minutes per person will be used as this is the factor that is used for the Camp Lejeune Naval Hospital, which is the facility that will be simulated later (Camp Lejeune Naval Hospital, 2009).

1. Variables

Patients from X base are vaccinated at Xh medical facility

Bases:	MTFs:
a= MCLB Albany	ah= MCLB Albany Branch Medical Clinic
c= MCAS Cherry Point	ch= MCAS Cherry Point MTF Naval Hospital Beaufort
l= MCB Camp Lejeune	lh= Naval Hospital Camp Lejeune
n= MCAS New River	nh= MCAS New River MTF
b= MCAS Beaufort	bnh= Beaufort Naval Hospital
p= MCRD Parris Island	bh= MCAS Beaufort MTF
q= MCB Quantico	ph= MCRD Parris Island MTF
	qh= Quantico Naval Health Clinic

2. Decision Variables

All numbers are patients vaccinated per day

Xa-ah= Number of patients from MCLB Albany that get vaccinated at MCLB Albany MTF

Xc-ch= Number of patients from MCAS Cherry Point that get vaccinated at MCAS Cherry Point MTF

Xl-lh= Number of patients from MCB Camp Lejeune that get vaccinated at Camp Lejeune Naval Hospital

Xn-nh= Number of patients from MCAS New River that get vaccinated at MCAS New River Medical Facility

Xn-lh= Number of patients from MCAS New River that get vaccinated at Camp Lejeune Naval Hospital

Xb-bh= Number of patients from MCAS Beaufort that get vaccinated at MCAS Beaufort MTF

Xb-bnh= Number of patients from MCAS Beaufort that get vaccinated at Beaufort Naval Hospital

Xp-bnh= Number of patients from MCRD Parris Island that get vaccinated at Beaufort Naval Hospital

Xp-ph= Number of patients from MCRD Parris Island that get vaccinated at MCRD Parris Island MTF

Xq-qh= Number of patients from Quantico that get vaccinated at Quantico Medical Facility

3. Objective Function

Minimize: 2[(Xa-ah+Xc-ch+Xl-lh+Xn-nh+Xn-lh+Xb-bh+Xb-bnh+Xp-bnh+Xp-ph+Xq-qh)(0.9)]

The sum of the number of patients is multiplied by a percentage (in this case 10%) to account for the estimate that planners must make as to how many patients they believe will receive vaccination elsewhere—such as dependents going to the local public health clinic or active duty patients that are deployed outside the region that will receive vaccine overseas. In this base model, the sum is multiplied by 0.9 to take 90% of the total, thus leaving out the 10%. This 10% estimate applies to the sum of all of the bases; a separate estimate could be applied to each base instead depending upon the situation.

The number of patients is multiplied by two minutes to get the minimum amount of time to vaccinate in minutes. Converted into hours, this calculates how many days it will take each MTF to vaccinate its respective populations based on how many workers they have at each MTF.

4. Capacity Constraints

Xa-ah ≤ Capacity at MCLB Albany MTF per day
Xc-ch ≤ Capacity at MCAS Cherry Point MTF per day
Xl-lh+Xn-lh ≤ Capacity at Camp Lejeune Naval Hospital per day
Xn-nh ≤ Capacity at MCAS New River MTF per day
Xb-bh ≤ Capacity at MCAS Beaufort MTF per day
Xp-ph ≤ Capacity at MCRD Parris Island MTF per day
Xp-bnh+Xb-bnh ≤ Capacity at Beaufort Naval Hospital per day
Xq-qh ≤ Capacity at MCB Quantico MTF per day

5. Requirements Constraints

Xa-ah ≥ Number of patients requiring vaccination at MCLB Albany
Xc-ch ≥ Number of patients requiring vaccination at MCAS Cherry Point

$Xl\text{-}lh \geq$ Number of patients requiring vaccination at MCB Camp Lejeune
$Xn\text{-}nh \geq$ Number of patients requiring vaccination at MCAS New River
$Xb\text{-}bh \geq$ Number of patients requiring vaccination at MCAS Beaufort
$Xp\text{-}ph \geq$ Number of patients requiring vaccination at MCRD Parris Island
$Xq\text{-}qh \geq$ Number of patients requiring vaccination at MCB Quantico
All decision variables non-negative

This model, when run by the Solver add-in for Microsoft Excel, will yield a result that shows the minimum amount of time to vaccinate the populations for each MTF while taking into account the possibility that some of the population will not receive vaccination at the base MTF. This minimized amount of time in minutes will allow planners to estimate the amount of time it will take to vaccinate their respective populations.

D. COMPUTER-BASED SIMULATION

Using data from the two models described, a computer-based model can be built to simulate the processes and estimate the amount of time it will take to achieve both the delivery phase and administration phase of vaccine in the event of a pandemic influenza outbreak. The software program used for this simulation is Arena 10.0. The Emergency Response Plan for MCB Camp Lejeune provided the data for the simulation. This simulation will include the patient population for MCB Camp Lejeune. The population size is based on the planning factor used to order vaccine amounts and do not take into account a probability of whether or not dependents will receive their vaccinations from the local health department. The software does encounter problems when attempting to simulate large numbers of entities through a process so for the purpose of this model 10% of the 124,000 population will be used.

1. Model Purpose and Objectives

This model is being constructed to measure the amount of time required for all Marine Corps active duty, dependents, and DoD civilian employees to receive vaccination. The scope of the model will cover one Marine Corps installation, MCB Camp Lejeune.

The objective of the model is to incorporate all processes from the arrival of vaccine at a distribution hub to finally being administered to a patient using only DoD transportation assets. The simulation will determine the feasibility of using only DoD assets for vaccine delivery.

2. Model Flow

An illustration of the process flow for vaccine delivery to MCB Camp Lejeune is depicted in Appendices A–E, which are screen shots of the model in the Arena 10.0 software. The process flow is as follows.

One entity, called "vaccine," is created at the Defense Supply Center Philadelphia. As pandemic influenza vaccine is developed, the vaccine could be received from a number of different locations: straight from the manufacturer, etc. (D. Neil, personal communication, August 27, 2009). This entity simulates the amount of vaccine that is required to vaccinate the sample population of 13,000 patients at MCB Camp Lejeune. To allow for expanding the model, the vaccine is identified for a certain destination, and its name is changed to reflect the region to which it is going (i.e., the Camp Lejeune vaccine is now called 'Cvaccine'). After the vaccine is identified by destination, a station is created at the Philadelphia airport and the plane and flight crew are seized. Of note, all entities, resources, variables, module names, etc. that are tied to a specific base or destination are identified by a letter—everything that is preceded by a "C" refers to a piece of the Camp Lejeune distribution process within the model. Using this type of identification will prevent confusion when other bases are added to the model. The loading plane process uses one loading crew and takes a triangularly distributed number of hours (.5, 1, 1.5, for example). See Appendix A.

Once the plane is loaded, a route is created to Wilmington International Airport taking a triangularly distributed number of (2, 3, 4) hours, which is then multiplied by a hurricane factor. A hurricane factor was created to simulate the likelihood of a hurricane striking the eastern seaboard of the United States and affecting the transportation of the vaccine to its respective destinations. The hurricane factor was created to appear randomly once every 45 days and to cause the hurricane to last for a uniformly distributed minimum of one day and maximum of four days. The uniform distribution being used in the hurricane factor is an attempt to create a real-world scenario that accounts for increased driving times due to severe weather and damage caused by a hurricane. All transportation times in the model are multiplied by this hurricane factor. See Appendix E.

To link the route from Philadelphia to Wilmington, a station was created at Wilmington. After the plane lands at the Wilmington Airport, two drivers and two MTVRs are seized to transport the vaccine to the Camp Lejeune Naval Hospital. The process of loading the vaccine from the plane onto the truck requires one unloading crew and takes a triangularly distributed number of (.5, 1, 1.5) hours. After the trucks are loaded with the vaccine, the plane and flight crew are released. See Appendix B.

A route is then created to simulate the driving time between Wilmington and the station destination, Camp Lejeune Naval Hospital. The drive time will take 1.5 hours multiplied by the hurricane factor. Once the trucks reach the Camp Lejeune Naval Hospital, the driver and MTVRs are then released. See Appendix C.

"Signal" and "hold" modules are used to create a second entity called 'Cpatients.' These modules simulate patients arriving to receive vaccination. They are released from the "hold" module when the trucks are leaving Wilmington in route to Camp Lejeune. The number of patients being created in Camp Lejeune is 13,000 and they arrive two per minute. Since the vaccine is delivered to the MTF as one entity, it is then separated into 13,000 doses of vaccine, one for each patient.

After the patients are created and the vaccine is separated, one dose of vaccine is then matched with one patient, and they are permanently batched together. This is to ensure every patient receives one vaccine and enables tracking of the number of patients receiving vaccine. To vaccinate each patient, one of 40 VS is seized to complete the vaccination process. The vaccination process for each patient requires one corpsman. There are 32 corpsmen available for 16 hours each day from 0800 through 0000. The vaccination process takes a triangularly distributed amount of time measured in minutes (1, 2, 2.5). After the vaccination process is complete, the patient room is released, the number of vaccinated patients, the total amount of time patients are in the system, and total amount of time the vaccine is in the system is recorded, and then the batched entity of a vaccinated patient is disposed. See Appendix D.

3. Resources

There are eight resources required for the Camp Lejeune model. One plane, flight crew, loading crew, and unloading crew are needed and available for the flight portion of the process. Two drivers and two MTVRs are needed and available for the driving portion of the process. There are 32 corpsmen and 40 VS available for administering vaccine (five VCs each containing eight VSs). The corpsmen work on a schedule that has a capacity of zero corpsmen for the first eight hours of the day and a capacity of 32 corpsmen for the next 16 hours of each day. Failures have been attributed to corpsmen to account for bathroom breaks (uniformly every four to seven hours for a time of five to seven minutes) and meal breaks (triangularly every six, eight, or 10 hours for a time of 20, 30, or 40 minutes). For the bathroom breaks, the rule applied is to complete the vaccination the corpsman is performing and then take the bathroom break for the amount of time remaining in the break. For the meal breaks, the rule applied is to complete the vaccination the corpsman is performing and then take their full meal break. The VS can also fail for an emergency, which is triangularly distributed between six, eight, or 10 hours and down for a period of five, 10, or 15 minutes. The rule for the VS emergency is to preempt, or stop at the time the emergency occurs and then resume vaccinations when the down time is complete.

4. Data

The data included in the model is derived from the population stationed aboard MCB Camp Lejeune, as well as the estimated travel time between Wilmington and the Camp Lejeune Naval Hospital. Specifically they include the following.

- Inter-arrival time of initial group of vaccine arriving at the airplane in Philadelphia (1 per hour)
- Amount of time to load vaccine on to the airplane (TRIA .5, 1, 1.5 hours)
- Hurricane factor—(UNIF 1, 4 days delay)
- Duration of the flight from Philadelphia to Wilmington—(TRIA 2, 3, 4 hours*hurricane factor)
- Amount of time to load the vaccine from the airplane on to an MTVR—(TRIA .5, 1, 1.5 hours)
- Amount of time for the MTVR to travel from Wilmington to Camp Lejeune Naval Hospital—(1.5 hours*hurricane factor)
- Amount of time to vaccinate one patient—(TRIA 1, 2, 2.5 minutes)
- Schedule of the corpsmen—(0 capacity for 8 hours, then a capacity of 32 for 16 hours)
- Failures of corpsmen
    - Bathroom breaks—(UNIF 4, 7 hours for up-time and UNIF 5, 10 minutes for down-time)
    - Meal breaks—(TRIA 6, 8, 10 hours for up-time and TRIA .33, .5, .67 hours for down-time)
- Failures of VS for emergencies (TRIA 6, 8, 10 hours for up-time and TRIA 5, 10, 15 minutes for down-time)

5. Variables to Track

Tracking the amount of time that the vaccine spends in the system allows planners to measure how long the process takes, from departing Philadelphia, to completing vaccination of the population at Camp Lejeune Naval Hospital. Measuring the amount of time that a patient spends in the system will allow us to adjust when patients are directed to proceed to the hospital for vaccination to avoid long waits for vaccination. In doing so, we can measure the average amount of time it takes each individual person to complete the vaccination process. Knowing this information would be beneficial for projecting how long it might take to vaccinate other affected residents of various bases.

6. Description of Experiments

a. Scenarios

1. Run the base model, no resource failures and no hurricane factor
2. Run the model with resource failures and no hurricane factor
3. Run the model with no resource failures but with a hurricane factor
4. Run the model with resource failures and a hurricane factor

b. Controls

1. VS availability—There are currently a total of 40 VS that would be established in the event of an outbreak for vaccinating personnel. To determine how the overall vaccination time would be affected, the number of VS was changed from 40 to 20. One of the reasons for modifying this resource was to see if reductions could be made in the amount of space being allocated for vaccinations without causing a significant increase in total vaccination time.
2. Replication length—The simulation replication length was changed from 168 hours or seven days to 72 hours or three days to simulate a SecDef or Commanding General mandate requiring shorter vaccination times. Simulating a reduction in the amount of time it takes to vaccinate all the personnel aboard base would provide valuable information to the SecDef or Commanding General. The SecDef or Commanding General needs to know the least amount of time it takes to vaccinate all of its personnel to ensure operational readiness.
3. Corpsmen—Camp Lejeune Naval Hospital currently has 32 corpsmen planned to be available to administer vaccines according to their emergency response plan. The total number of corpsmen was doubled to 64 to see how an increase in manpower would improve vaccination time.

c. Number of Replications

When determining the number of replications the model needs to run, it was concluded that the amount of time each patient spent in the system is the most important variable that needed to be tracked. After running each model 10 times, the largest half-width for total patient vaccination time was 2.11 hours. The desired half-width or the greatest amount of variance that is acceptable for each model is 0.25 hours or 15 minutes. The number of replications needed to achieve this half-width is 712.6 or 713. This calculation was made by using the following formula: $N = n_o (h_o)^2/h^2$, where:

N = number of replications to achieve the desired half-width

H = desired half-width

n_o = original number of replications

h_o = original half-width

7. Results and Analysis

Each of the four scenarios above was run by the Process Analyzer function in Arena 10.0. (See Appendix F) By adjusting the controls each scenario, a total of 32 scenarios were run in all. For the model that did not have a hurricane or any failures, the optimal number of VS, replication length, and corpsmen available is 40, 72, and 64 respectively; yielding an average patient vaccination time of 6.455 hours with a confidence interval of 0.25 hours or less. Regardless of the number of corpsmen available, reducing the number of VS by half, to 20, causes the average patient vaccination time to nearly double (12.966 hours).

Similar results were found in each of the remaining models. They showed that the number of VS available is the limiting constraint in the average amount of time a patient will spend in the system. This is the case regardless of whether or not there is a hurricane. However, when a hurricane is introduced into the model, three days is an insufficient amount of time to vaccinate all 13,000 personnel. The total vaccination time to vaccinate all patients increased to an average 5.5 days when a hurricane delayed the travel time of the vaccine to Camp Lejeune Naval Hospital.

E. CHAPTER SUMMARY

This chapter outlined the variables to be considered in developing a vaccine distribution network using only DoD transportation assets. The two models introduced can be used by planners in any environment by inserting the applicable data to calculate transportation and vaccination times for an affected population. Conducting a computer simulation also yields adequate results for estimating the process flow and time, in place of simulation using actual assets that costs manpower, resources, and time.

THIS PAGE INTENTIONALLY LEFT BLANK

V. DISCUSSION, CONCLUSION, AND RECOMMENDATION

A. MODEL APPLICATION FOR MULTIPLE ENVIRONMENTS

The models described in Chapter IV can be applied across a variety of operational environments. Transportation assets to be utilized to deliver vaccine can be determined by their availability and the distances that they are required to travel. When available, helicopter assets should be the preferred method of delivery. Table 2 contains the template for the installation description matrix populated Chapter III can be used to collect relevant data for modeling the pandemic influenza transportation and vaccination models.

Installation	Population	Nearest Hub (Airport)	Distance to Hub	Transportation Assets Required	Transportation Assets Available	Transportation Time (Ground)	Transportation Time (Air)	Number of Medical Staff Available	Hours/Day for Vaccination

Table 2. Installation Description Matrix Template

B. CONCLUSION

An outbreak of pandemic influenza could severely affect the military's operational capability. After completing this study, the following conclusions have been made.

- The DoD is heavily dependent on commercial delivery companies for the transportation of vaccine in the event of a pandemic influenza
- The use of DoD assets to deliver vaccine from the arrival airport to the MTF is feasible, but identification of these assets must be made clear in the planning phase

- There is currently no plan in place to use DoD assets for vaccine transportation in the event that commercial vaccine delivery is compromised
- The vaccine ordering process is dynamic because MTF planners aboard military installations do not have an accurate way to calculate how much vaccine to order because of the multiple locations that dependents and enrolled civilians can receive vaccination.

C. RECOMMENDATIONS

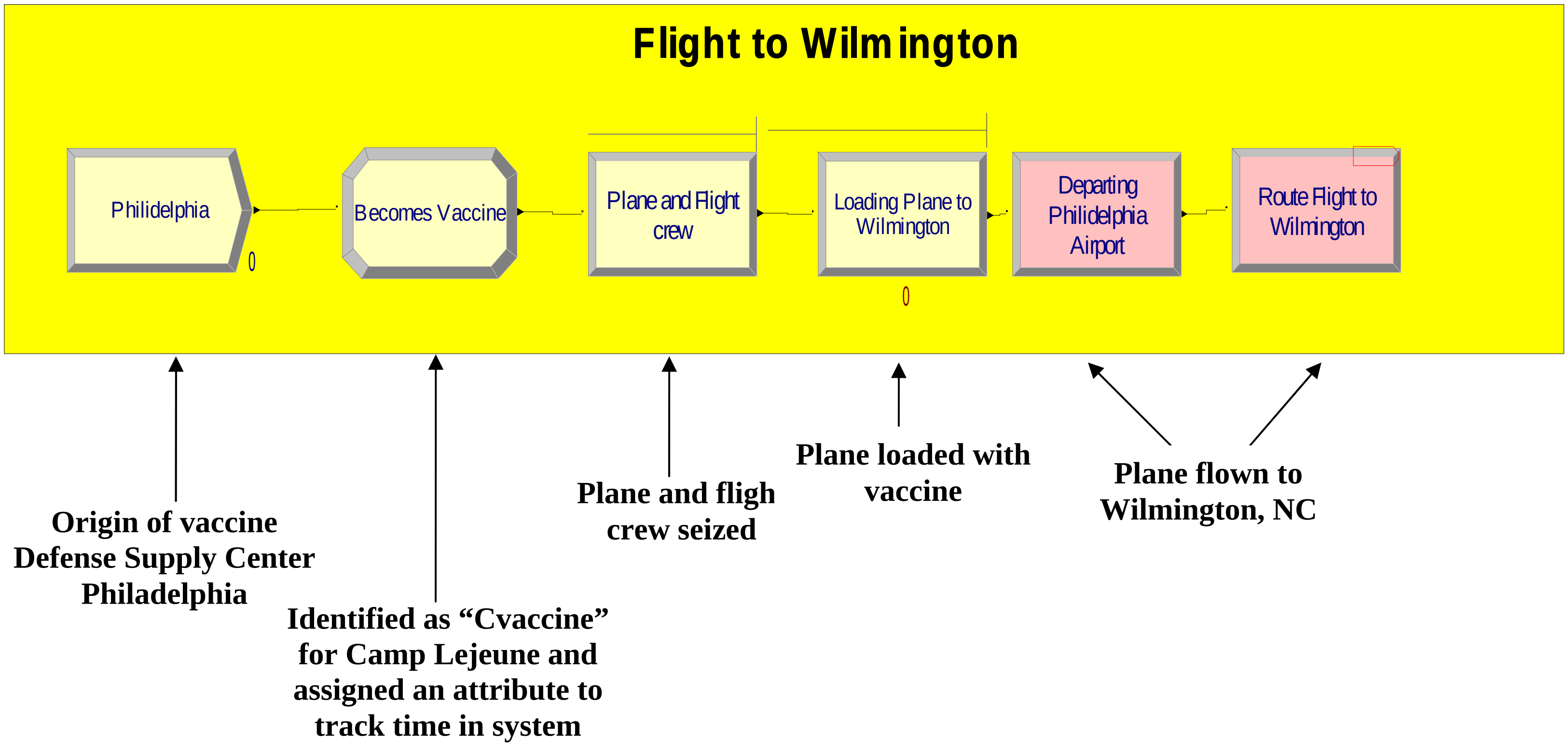
As a result of the current process in place, it is recommended that the DoD work to implement a vaccine distribution process that is uniform throughout the various services using a common planning tool. The same planning tool should be used to ensure that multiple processes are not being implemented that delay the distribution flow in the event of an outbreak. Less dependence on commercial vendors for vaccine transport is essential.

After a consistent distribution process is implemented, it must be tested. Computer simulations save time and money, but they are not sufficient to test an operation of this scope. Like all military operations, this distribution process must be rehearsed and tested for feasibility before a true outbreak occurs. Failure to ensure this capability could not only potentially cost lives but also threaten national security.

D. RECOMMENDATIONS FOR FURTHER STUDY

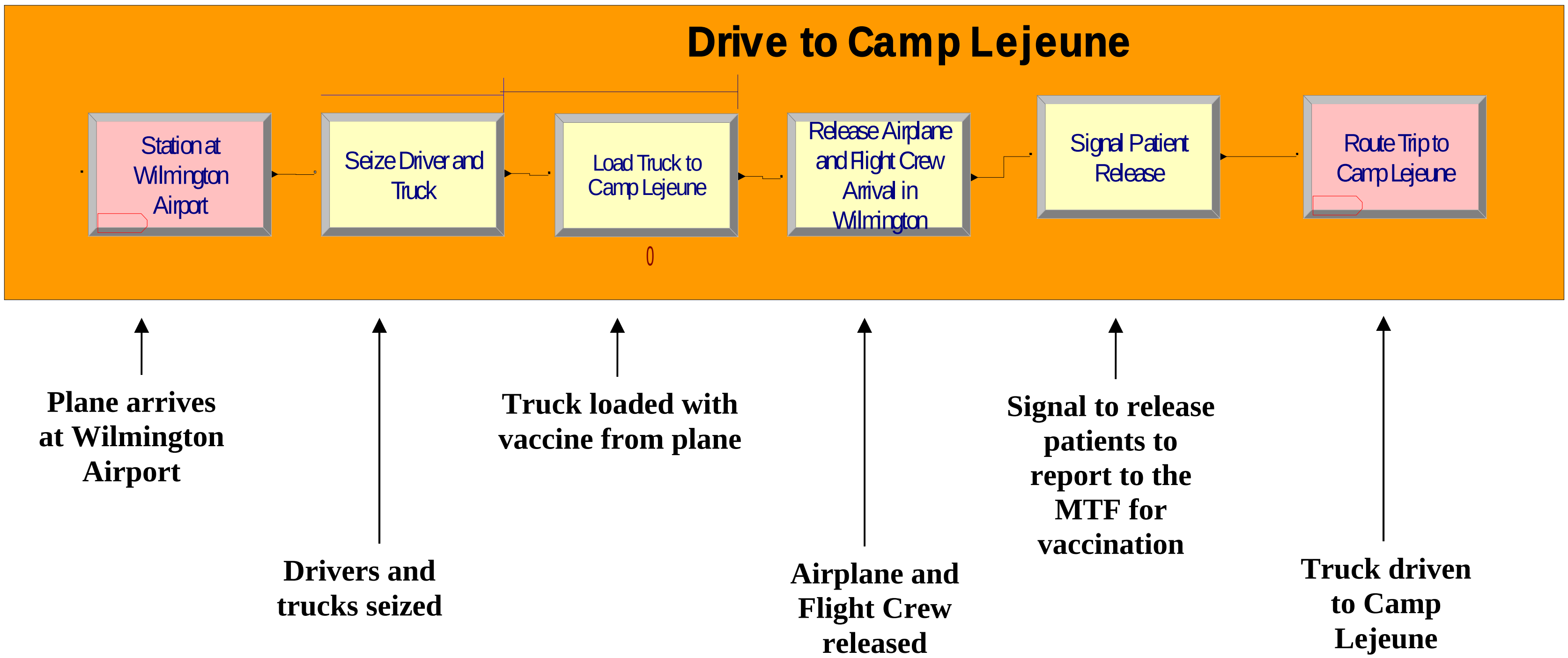
Further study is needed to compare the amount of time that commercial delivery companies take to deliver vaccine versus the amount of time it would take to do so using DoD transportation assets. With the uncertainty of cost being a factor in the future, it is also recommended that the cost of different distribution processes be analyzed as any potential operation would have to have budgetary considerations for assets and training resources.

APPENDIX A.


Flight to Wilmington
Philidelphia
0
Becomes Vaccine
Plane and Flight crew
Loading Plane to Wilmington
0
Departing Philidelphia Airport
Route Flight to Wilmington
Origin of vaccine
Defense Supply Center
Philadelphia
Identified as “Cvaccine”
for Camp Lejeune and
assigned an attribute to
track time in system
Plane and fligh
crew seized
Plane loaded with
vaccine
Plane flown to
Wilmington, NC

THIS PAGE INTENTIONALLY LEFT BLANK

APPENDIX B.

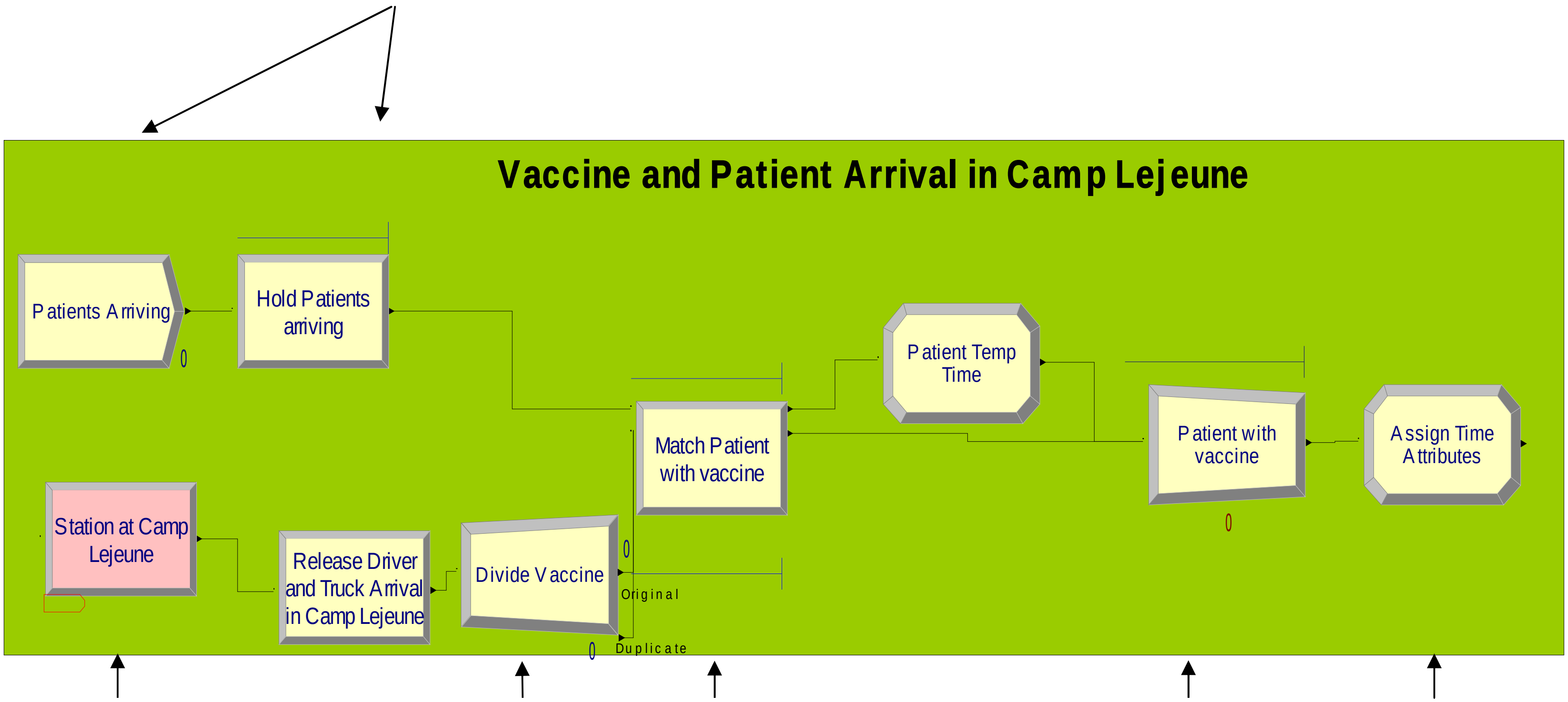


Drive to Camp Lejeune
Station at Wilmington Airport
Seize Driver and Truck
Load Truck to Camp Lejeune
0
Release Airplane and Flight Crew Arrival in Wilmington
Signal Patient Release
Route Trip to Camp Lejeune
Plane arrives at Wilmington Airport
Drivers and trucks seized
Truck loaded with vaccine from plane
Airplane and Flight Crew released
Signal to release patients to report to the MTF for vaccination
Truck driven to Camp Lejeune

THIS PAGE INTENTIONALLY LEFT BLANK

APPENDIX C.

13,000 patients created and held for signal to release



Truck arrives at Camp Lejeune Naval Hospital

Vaccine is separated into 13,000 doses

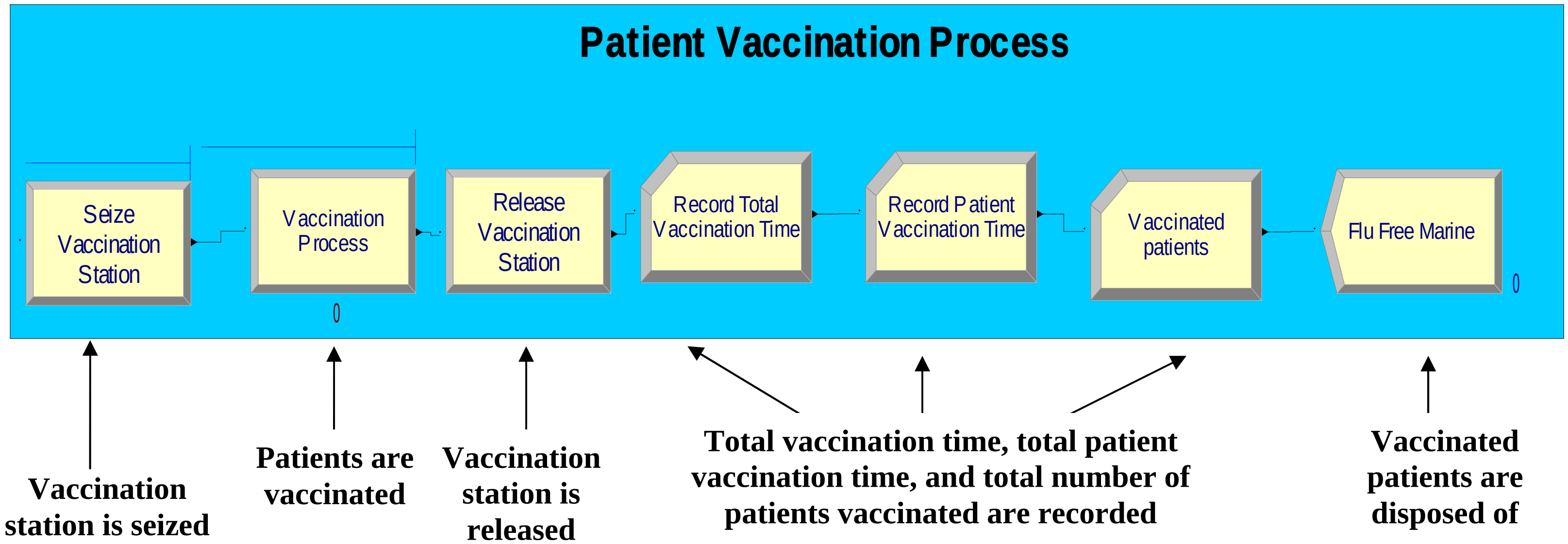
Each dose of vaccine is matched with a patient

Patients and vaccine are batched

Each patient is assigned an attribute to track

THIS PAGE INTENTIONALLY LEFT BLANK

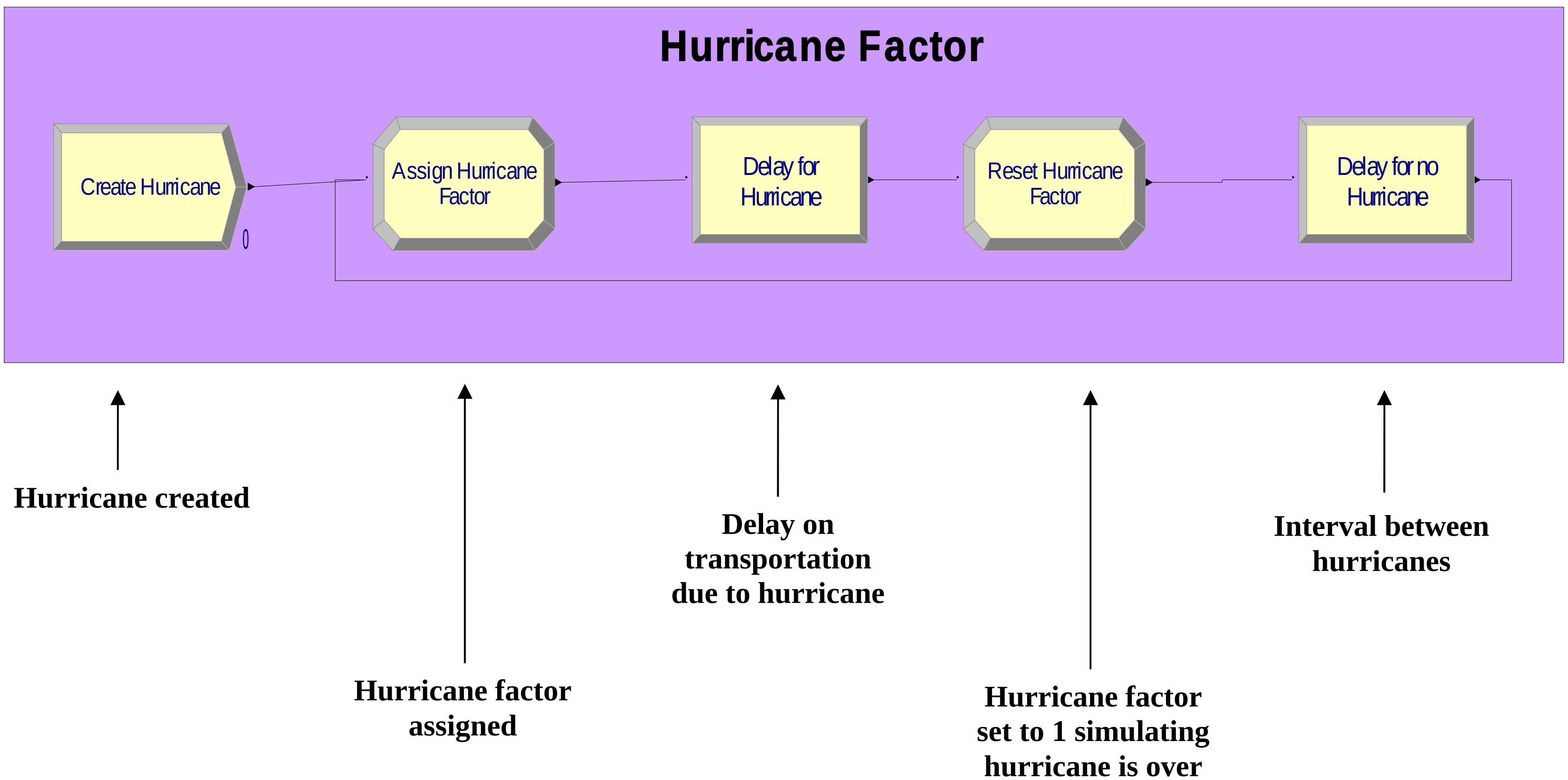
APPENDIX D.



Patient Vaccination Process
Seize Vaccination Station
Vaccination Process
Release Vaccination Station
Record Total Vaccination Time
Record Patient Vaccination Time
Vaccinated patients
Flu Free Marine
Vaccination station is seized
Patients are vaccinated
Vaccination station is released
Total vaccination time, total patient vaccination time, and total number of patients vaccinated are recorded
Vaccinated patients are disposed of

THIS PAGE INTENTIONALLY LEFT BLANK

APPENDIX E.



Hurricane Factor
Create Hurricane
0
Assign Hurricane Factor
Delay for Hurricane
Reset Hurricane Factor
Delay for no Hurricane
Hurricane created
Hurricane factor assigned
Delay on transportation due to hurricane
Hurricane factor set to 1 simulating hurricane is over
Interval between hurricanes

THIS PAGE INTENTIONALLY LEFT BLANK

APPENDIX F.

Scenario	Hurricane	Failure	Patient Rooms	Rep Length	Corpsman Cap	Reps	Patient Number In	Patient Number Out	Vaccination Queue Waiting Time	Vaccination number in Queue	Patient Room Utilization	Patient vaccination Time	Number Vaccinated Patients
Scenario 1	N	N	40	168	32	713	13000	13000	0.012	0.941	0.083	7.696	13000
Scenario 2	N	N	40	168	64	713	13000	13000	0.005	0.351	0.068	6.455	13000
Scenario 3	N	N	40	72	32	713	13000	13000	0.012	2.197	0.193	7.696	13000
Scenario 4	N	N	40	72	64	713	13000	13000	0.005	0.820	0.158	6.455	13000
Scenario 5	N	N	20	168	32	713	13000	13000	0.015	1.126	0.175	12.966	13000
Scenario 6	N	N	20	168	64	713	13000	13000	0.015	1.126	0.175	12.966	13000
Scenario 7	N	N	20	72	32	713	13000	13000	0.015	2.628	0.407	12.966	13000
Scenario 8	N	N	20	72	64	713	13000	13000	0.015	2.628	0.407	12.966	13000
Scenario 9	N	Y	40	168	32	713	13000	13000	0.015	1.151	0.088	8.327	13000
Scenario 10	N	Y	40	168	64	713	13000	13000	0.007	0.571	0.073	6.988	13000
Scenario 11	N	Y	40	72	32	713	13000	13000	0.015	2.687	0.205	8.327	13000
Scenario 12	N	Y	40	72	64	713	13000	13000	0.015	2.687	0.205	8.327	13000
Scenario 13	N	Y	20	168	32	713	13000	13000	0.017	1.301	0.183	14.461	13000
Scenario 14	N	Y	20	168	64	713	13000	13000	0.017	1.301	0.183	14.461	13000
Scenario 15	N	Y	20	72	32	713	13000	13000	0.017	3.037	0.428	14.461	13000
Scenario 16	N	Y	20	72	64	713	13000	13000	0.017	3.037	0.428	14.461	13000
Scenario 17	Y	N	40	168	32	713	13000	13000	0.025	1.955	0.108	9.717	13000
Scenario 18	Y	N	40	168	64	713	13000	13000	0.015	1.174	0.088	8.006	13000
Scenario 19	Y	N	40	72	32	713	8058.906	6838.569	0.012	2.007	0.123	4.714	6835
Scenario 20	Y	N	40	72	64	713	8058.906	7084.097	0.006	1.135	0.104	3.967	7084
Scenario 21	Y	N	20	168	32	713	13000	13000	0.016	1.248	0.181	15.166	13000
Scenario 22	Y	N	20	168	64	713	13000	13000	0.016	1.248	0.181	15.166	13000
Scenario 23	Y	N	20	72	32	713	8058.906	6085.574	0.006	0.981	0.178	6.665	6086
Scenario 24	Y	N	20	72	64	713	8058.906	6085.574	0.006	0.981	0.178	6.665	6086
Scenario 25	Y	Y	40	168	32	713	13000	13000	0.028	2.190	0.114	10.195	13000
Scenario 26	Y	Y	40	168	64	713	13000	13000	0.017	1.336	0.092	8.382	13000
Scenario 27	Y	Y	40	72	32	713	8824.684	7918.952	---	2.754	0.153	---	7919
Scenario 28	Y	Y	40	72	64	713	8824.684	8116.243	---	1.610	0.126	---	8116
Scenario 29	Y	Y	20	168	32	713	13000	13000	0.019	1.485	0.192	16.339	13000
Scenario 30	Y	Y	20	168	64	713	13000	13000	0.019	1.485	0.192	16.339	13000
Scenario 31	Y	Y	20	72	32	713	8824.684	6901.017	---	1.368	0.215	---	6901
Scenario 32	Y	Y	20	72	64	713	8824.684	6902.017	---	1.368	0.215	---	6901

THIS PAGE INTENTIONALLY LEFT BLANK

LIST OF REFERENCES

Balcick, B. S., Beamon, B. M., & Smilowitz, K. (2008). Last mile distribution in humanitarian relief. *Journal of Intelligent Transportation Systems*, *12*(2), 51–63.

Camp Lejeune Naval Hospital. (2005). *Annex H to NAVHOSPCAMLEJINST 3440.1J emergency management plan.* Camp Lejeune, NC: Author.

Centers for Disease Control. (2009). *Seasonal influenza: The disease.* Retrieved June 4, 2009, from http://cdc.gov/flu/about/disease/

Department of Defense (DoD). (2006). *Department of Defense implementation plan for pandemic influenza.* Washington, DC: Office of the Assistant Secretary of Defense for Homeland Defense.

Federation of American Scientists. (2007). *Characteristics of the Ch-53 Sea Stallion.* Retrieved July 12, 2009, from http://www.fas.org/programs/ssp/man/uswpns/air/rotary/h53.html

Government Accountability Office (GAO). (2007). *Influenza pandemic: DoD combatant commands' preparedness efforts could benefit from more clearly defined roles, resources, and risk mitigation* (GAO-07-696). Washington, DC: General Accounting Office.

Gurr, J. R. (2006). *A model for the ordering and distribution of the Influenza Vaccine* (Master's Thesis). Monterey, CA: Naval Postgraduate School.

H1N1 Flu Update. (2009, June 9). Retrieved June 15, 2009, from http://www.cdc.gov/h1n1flu/update

Health and Human Services. (2005). *Health and human services pandemic influenza plan.* Washington, DC: Office of the Secretary of Health and Human Services.

Homeland Security Council. (2005). *National strategy for pandemic influenza.* Washington, DC: Office of the Secretary of Defense.

Homeland Security Council. (2006). *National strategy for pandemic influenza implementation guide.* Washington, DC: Office of the Secretary of Defense.

Jones, D., & Tecmire, C. (2007). *Cold-chain logistics: A study of the Department of Defense OCONUS pre-pandemic influenza vaccine distribution network* (MBA Project). Monterey, CA: Naval Postgraduate School.

Lee, E., Smalley, H., Zhang, Y., Pietz, F., & Benecke, B. (2009). Facility location and multi-modality mass dispensing strategies and emergency response for biodefence and infectious disease outbreaks. *International Journal of Risk Assessment and Management, 12*(2–4), 311. Retrieved August 17, 2009, from ABI/INFORM Global (Document ID: 1731890641).

Oshkosh Corporation. (2008). *MTVR characteristics brochure.* Retrieved July 12, 2009, from http://www.oshkoshdefense.com/pdf/Oshkosh_MTVR_brochure.pdf

Snacken, R., Kendal, A. P., Haaheim, L. R., & Wood, J. M. (1999, March–April). The next influenza pandemic: Lessons from Hong Kong, 1997. *Emerging Infectious Diseases*, *5*(2). Retrieved June 10, 2007, from http://www.cdc.gov/ncidod/eid/vol5no2/snacken.htm

World Health Organization (WHO). (2009). *Pandemic influenza preparedness plan.* Retrieved September 14, 2009, from http://www.who.int/csr/disease/influenza/PIPGuidance09.pdf

INITIAL DISTRIBUTION LIST

1. Defense Technical Information Center
   Fort Belvoir, Virginia

2. Dudley Knox Library
   Naval Postgraduate School
   Monterey, California

3. Marine Corps Representative
   Naval Postgraduate School
   Monterey, California

4. Director, Training and Education, MCCDC, Code C46
   Quantico, Virginia

5. Director, Marine Corps Research Center, MCCDC, Code C40RC
   Quantico, Virginia

6. Marine Corps Tactical Systems Support Activity (Attn: Operations Officer)
   Camp Pendleton, California